Water Power Resources of Canada

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

WATER RESOURCES BRANCH

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BULLETIN No. 2702

OTTAWA, 15 March 1960

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The Water Resources Branch, Department of Northern Affairs and National Resources, presents its annual review of the water power resources of Canada and of their development to the end of 1959. Based upon the Branch's water power inventory, resources are summarized and such salient features as provincial and territorial distribution, current progress of construction, rate of development, and industrial utilization are discussed briefly.

One of the most important factors influencing Canada's economic development has been the availability of large quantities of low-cost electric power derived from the nation's water power resources. Since early in the present century water power has increased Canada's productive capacity at a remarkable rate. In less than fifty years an economy which was essentially agricultural and which produced mainly raw materials for export has changed to one increasingly dependent upon industrial operations. This transition, coincident with the growth of water power development, has been accelerating in recent years. The close relationship between water power and industry in Canada is particularly evident in southern Quebec and Ontario which, although lacking in indigenous coal, have become the most highly industrialized regions of the country through the use of their large water power resources. The Province of British Columbia, which is rich in potential water power, also has been making rapid industrial progress in step with water power development. Most of the current power demand in Canada is provided by hydro-electric developments and in 1959 the installation of 2,508,800 hp. of new hydro-electric capacity established for the second consecutive year a maximum record in the amount of such capacity brought into operation during a period of one year. Considerable additional hydro-electric capacity is currently under construction for initial operation during the next few years. In some areas of the country, however, there is a growing tendency towards increased thermal-electric generation which reflects not only a stage of hydro-electric development wherein remaining undeveloped sites are becoming more remote from established demand areas but also the benefits of resource conservation which may be derived through operation of an integrated power system supplied by both hydro-electric and thermal-electric plants.

Copies of this annual bulletin may be obtained free of charge from the Director, Water Resources Branch, Department of Northern Affairs and National Resources, Ottawa.

TOTAL AVAILABLE AND DEVELOPED WATER POWER

The following Table I lists by province and territory the total water power resources of Canada and the present total capacity of all water power plants in the country, as determined from the records of the Water Resources

Branch. The Branch, under agreements with provincial authorities, carries out hydrometric investigations on rivers throughout the country and maintains continuous records of stream flow as accumulated from all sources. The estimates of available power are revised as stream-flow records accumulate for longer periods and more detailed information on potential power sites is obtained; as defined on the following pages, estimates are made on the bases of ordinary minimum flow and dependable maximum (ordinary six-months) flow. Regarding information on developed water power and power output, close liaison is maintained with the Dominion Bureau of Statistics. The totals of installed horsepower capacity are based upon the manufacturer's rating of each turbine and water wheel, where this information is available.

TABLE I

AVAILABLE AND DEVELOPED WATER POWER IN CANADA

At End of the Year 1959

Province or Territory	Available continuous power at 80% efficiency - hp.		Installed Turbine Capacity hp.
	At Ordinary Min. Flow	At Ordinary 6-Months Flow	
1	2	3	4
British Columbia	18,200,000*	19,400,000*	3,509,460
Alberta	911,000	2,453,000	312,595
Saskatchewan	550,000	1,120,000	128,835
Manitoba	3,492,000	5,798,000	778,900
Ontario	5,496,000	7,701,000	7,982,151
Quebec	10,896,000**	20,445,000**	11,315,407
New Brunswick	123,000	334,000	254,875
Nova Scotia	30,500	177,000	183,168
Prince Edward Island	500	3,000	1,660
Newfoundland	1,608,000	3,264,000	370,135
Yukon Territory	4,678,000*	4,700,000*	38,190
Northwest Territories	374,000	808,000	13,050
Canada	46,359,000*	66,203,000*	24,888,426

* These figures reflect the effect of possible stream flow regulation based on known storage potentials.

** These figures undoubtedly will be revised substantially with the completion of the review of water power resources which the Quebec Department of Hydraulic Resources now has under way and in which the Water Resources Branch is co-operating.

Columns 2 and 3 in the above table do not include the power potential of major river diversions that have been investigated but not developed; for example, in the province of British Columbia the potential of the Chilko River itself has been included, but not the potential of the Chilko-Homathko River diversion which some publications quote as 1,000,000 hp. A number of other major diversion possibilities exist particularly in British Columbia where topographical conditions favour such rearrangements of flow. The

addition of the power potential of these major diversions to the available power figures given in the preceding table may be necessary in some instances to reconcile these figures with those obtained from other sources.

Column 2 lists the estimated continuous power ordinarily available at periods of low discharge under existing conditions of river flow; the "Ordinary Minimum Flow" is based upon the average of the mean flows for the two lowest periods of seven consecutive days in each year covered by the period of record. Estimates of dependable maximum power, Column 3, are based upon the "Ordinary Six-Months Flow" which is the computed dependable stream flow usually available for at least six months in the year under existing flow conditions. On rivers for which there are no specific discharge records, estimates of flow are made from all available pertinent information relating to runoff in the area.

With respect to hydraulic head, the figures of Columns 2 and 3 are based upon the actual drop, or feasible concentration of head, which has been measured or at least carefully estimated at existing falls, rapids and known power sites; no consideration has been given to possible economic concentrations of head on rivers and streams of gradual gradient, except at those locations where the feasible head has been definitely established by field investigations. Many unrecorded power sites exist on rivers and streams throughout the country, particularly in the less explored northerly districts, but these cannot be included in the tabulation until more detailed survey work has been made. Thus, regarding both the total number of sites and the possible head at each site, the listed figures of available power represent only the minimum water power possibilities of Canada.

The figures for installed turbine capacity, listed in Column 4, are the totals of plant capacities based upon the manufacturer's rating as indicated on the name-plate of each unit. In exceptional instances where, subsequent to the initial development, a change in the normal operating head has been effected, a rating based on the new normal operating head is used. While the maximum economic turbine installation at any power site can be determined only by careful consideration of all conditions and circumstances pertinent to its individual development, it is usual practice to install turbines which have a total capacity in excess of the power equivalent of the ordinary six-months flow at the site. This additional capacity may be installed for use at peak-load hours, to take advantage of periods of high river flow, or to facilitate plant maintenance. In some instances, subsequent to initial development, storage dams have been built to provide more uniform river flows. In others, deficiencies in power output during periods of low flow have been mitigated by interconnection with other hydro-electric plants which operate under different load conditions, or which are located on other rivers with different flow characteristics; or by auxiliary power from thermal plants.

Depending upon the factors which govern the system of power plant operation the extent to which the installed capacity exceeds the power equivalent of the ordinary six-months flow varies widely in different areas of the country and in some individual developments may amount to as much as several hundred per cent. For this reason the figures in Column 4 are not directly comparable with those of Column 3. From a review of the installed capacities at many hydro-electric developments across the country,

it is estimated that the 66,203,000 hp. of available water power in Canada will permit a feasible turbine installation of over 87,000,000 hp. which is more than three times the present turbine installation.

Although extensive use of Canada's water power resources is being made at the present time, large potential power sites have yet to be developed in various parts of the country. In some areas, where the more attractive sites within economic transmission distances of present centres of population already have been developed, the expansion of thermal-electric development is necessary to satisfy the increasing power demand. In other areas, reserves of accessible power continue to meet the prospective power requirements of a considerable part of the more densely settled areas; also, improvements in the techniques of long-distance transmission, including the use of higher voltage, are bringing additional sites within the orbit of existing systems. In more remote districts, water power will facilitate the utilization of mineral and other resources and promote the establishment of new communities. From the viewpoint of moving Canada's frontiers northward, the availability of considerable amounts of potential water power in the northern regions of the country is a definite advantage.

PROVINCIAL AND TERRITORIAL DISTRIBUTION OF WATER POWER

Table I on page 2 shows the provincial and territorial distribution of Canada's available and developed water power. A review of this table illustrates that considerable amounts of water power are being used in all provinces except Prince Edward Island where resources are small. As the development of Canada's natural resources proceeds, the fortunate incidence of water power in proximity to mineral deposits, pulpwood, and other natural resources becomes more apparent.

British Columbia, traversed by three distinct mountain ranges and with, on the whole, a high rate of precipitation, has many mountain rivers which offer opportunity for power development. The province ranks second in presently recorded available resources and is exceeded only by Quebec and Ontario in installed capacity. Considerable power potential exists principally on such rivers as the Columbia, Fraser, Peace and the Stikine. A large part of present development is located in the southern portion of the province, but the largest single development is the Kemano plant of the Aluminum Company of Canada with a present capacity of 1,050,000 hp. The British Columbia Electric Company Limited is the major hydro-electric producer and distributor in the province. The British Columbia Power Commission, which was organized in 1945, also has become an important power-producing and distributing agency.

In Alberta, the principal hydro-electric developments from which Calgary Power Limited serves a large part of the southern portion of the province, are located on the Bow River and its tributaries. A substantial share of the water power resources is located in the northern half of the province, rather remote from present centres of population. Large reserves of coal, oil and natural gas located in the province supply a very substantial portion of its power requirements.

In Saskatchewan, abundant water power resources are located in the northern part of the province, principally on the Churchill and Fond du Lac Rivers and on the Saskatchewan River. The existing water power developments

are confined to mining uses in the northern areas. However, new developments, now under construction on the Saskatchewan River, will be tied into the transmission network of the Saskatchewan Power Corporation of the Provincial Government which serves the more settled areas of the province and which at present is supplied exclusively by thermal-electric plants. As in Alberta, the substantial reserves of coal, oil and natural gas located in the province supply much of its power requirements, particularly in the southern part of the province.

Of the Prairie Provinces, Manitoba has the largest water power resources, there being great potential power on the Churchill, Nelson, and Saskatchewan Rivers. The larger present developments are located on the Winnipeg River, now fully developed, and serve Winnipeg, adjacent municipalities, and the transmission network of the Manitoba Power Commission. Increasing amounts of thermal-electric power are being used to meet the increasing power demands of the southern part of the province.

Ontario has large water power resources, being exceeded in this respect only by Quebec and British Columbia. It has developed the greater part of its recorded available power and ranks second in water power development among the provinces. The Hydro-Electric Power Commission of Ontario is the greatest power-producing and distributing organization in Canada and operates 69 hydro-electric generating stations with a total installed capacity of over 7,000,000 hp. and two thermal-electric stations with a combined generating capacity of more than 700,000 kw. Its largest water power development is located on the Niagara River at Queenston where the total capacity of the Sir Adam Beck-Niagara Generating Stations Nos.1 and 2 and associated pumping-generating station is 2,521,000 hp. The Commission also purchases nearly 1,000,000 hp. on contract.

The Province of Quebec is the richest in water power resources, containing more than 30 per cent of the total recorded for Canada. Quebec also ranks highest in developed power, its present installation of 11,315,407 hp. being about 45 per cent of the total for all provinces and representing the development of probably less than 40 per cent of its feasible turbine installation. The largest single hydro-electric installation in Canada is the Quebec Hydro-Electric Commission's Beauharnois development on the St. Lawrence River with a capacity of 1,718,800 hp. installed to date. Also notable are the Commission's Bersimis I development on the Bersimis River with an installed capacity of 1,200,000 hp. and the Shipshaw plant of the Aluminum Company of Canada Limited on the Saguenay River which is rated at 1,200,000 hp. Power production in the province is greatly facilitated by the regulation of stream flow by the Quebec Department of Hydraulic Resources through the storage dams it operates or controls.

The water power resources of New Brunswick and Nova Scotia, although small in comparison with those of other provinces, constitute a valuable source of power of which considerable use is being made; both provinces have numerous rivers upon which moderate-sized power sites exist within economic transmission distance of the principal cities and towns; other sites are advantageously situated for use in development of the timber and mineral resources. These provinces also are favoured with abundant indigenous coal supplies. In Prince Edward Island, there are no large streams and consequently water power sites are limited in size to those used for small mills.

On the basis of the limited stream-flow data available, Newfoundland's water power resources are estimated to be of considerable magnitude. On the Island, although the rivers are short, topography and runoff conditions are favourable to power development; in Labrador, the Hamilton River has a high power potential which comprises one of the largest undeveloped sources of water power in Canada. Considerable development has taken place on the Island, the larger developments having been constructed to serve the pulp and paper industry.

The two Territories which comprise Canada's vast northland possess extensive water power resources although, owing to light precipitation, the favourable sites are dependent upon large storage capacities. In the Yukon Territory, most of the resources are located on the Yukon River and its tributaries. There exists also the possibility of diverting the headwaters of the Yukon River through the Coast Mountains to utilize a high head near tidewater in northern British Columbia; however, such a development would affect adversely the power potential of the Yukon River in the Yukon Territory. In the Northwest Territories, resources are of considerable magnitude and more than one-half of the total amount occurs on rivers flowing into Great Slave Lake. Present development is limited to local mining uses and the supply of attendant settlements. Owing to the lack of developed native fuel sources and to transportation difficulties, water power is of special importance in the development of mining areas such as Yellowknife, Northwest Territories and Mayo, Yukon Territory. To encourage the development of the resources of northern Canada, the Federal Government established in 1948 an agency now known as the Northern Canada Power Commission for the construction and management of public utility plants. The Deputy Minister of Northern Affairs and National Resources is Chairman of this Commission and the Director of the Water Resources Branch is a Member.

PROGRESS IN DEVELOPMENT DURING 1959

For the second consecutive year, a maximum record was established in the amount of new hydro-electric generating capacity brought into operation during a single calendar year. A total of 2,508,800 hp. of new capacity was installed during 1959; other installations which are currently under construction are expected to add about 1,700,000 hp. during 1960 while an additional 2,300,000 hp. of new capacity are either under construction or in active prospect for development in succeeding years.

A detailed review of new and prospective developments was given in the Branch's bulletin No.2700 "Hydro-Electric Progress in Canada, 1959" which was issued on 31 December 1959. Copies of this bulletin are still available, free of charge, upon request. The following is a brief list of the hydro-electric developments completed or under construction during 1959 or proposed for initial construction in the succeeding few years:

British Columbia

1. British Columbia Power Commission
   (a) Ash River development, Ash River: Completed in June 1959 with the installation of a single unit of 35,000 hp.
   (b) In the planning stages only: Kokish River development on Vancouver Island where a total installation of 51,500 hp. is anticipated; Pyramid Mountain-Murtle River development which will consist initially of one 43,000-hp. unit with ultimate development expected to reach four units of 43,000 hp. each.

2. British Columbia Electric Company Limited

Bridge River No.2: Work continued on final phase of development including construction of Mission Dam on the Bridge River. Initial operation at the new power house commenced late in 1959 with the completion of two units at 82,000 hp. each. Two similar units will be added in 1960 raising to 328,000 hp. the total installed capacity at the new plant. Mission Dam will raise the head at Bridge River No.1, increasing its output from 248,000 hp. to 276,000 hp.

3. Northern British Columbia Power Company Limited

Falls River development, Big Falls Creek: Installation of a 6,000-hp. unit is planned for completion before November 1960, raising to 12,000 hp. the total installed capacity at the plant.

4. City of Revelstoke

Cranberry Creek: The City plans to develop a site about 15 miles south of Revelstoke to consist initially of one unit at 5,700 hp. Provision will be made for a second similar unit.

5. Peace River Development Company

Peace River above Hudson Hope: Planning of this project was continued. Preliminary plans indicate that the project will consist in part of a main storage dam where hydro-electric facilities under a maximum operating head of 600 feet will provide a generating capacity of about 2,500,000 kw. A second dam and hydro-electric plant is expected to be developed downstream from the main dam.

6. Northwest Power Industries Limited

An active interest was maintained in the Yukon River power project and in the Nass River project. Review of certain main features of the Nass River project was undertaken and estimates for both projects were revised in the light of changes in labour and material costs.

7. Columbia River

Active negotiations are proceeding between the Governments of Canada, British Columbia and the United States looking to early development of the Columbia River in Canada.

Alberta

1. Calgary Power Limited

(a) Spray and Rundle, Bow River: Construction was resumed for the extension of these plants. The capacity of the Spray plant will be doubled by the addition of a 62,000-hp. unit. A 40,000-hp. unit will be added to the existing capacity of 23,000 hp. at the Rundle plant. Both plants are scheduled for completion in October 1960.

(b) Brazeau River: Construction was begun to install a single 200,000-hp. unit at Big Bend, about 15 miles upstream from the confluence with the North Saskatchewan River. Plans call for the future installation of additional units of the same size to an ultimate capacity of 800,000 hp.

(c) North Saskatchewan River: Preliminary investigations are under way for a hydro-electric development at the Brazeau Forks site, below the confluence with the Brazeau River.

Saskatchewan

1. Churchill River Power Company Limited

Island Falls, Churchill River: Completed in June 1959 with the installation of a 19,000-hp. unit increasing the installed turbine capacity to 125,500 hp. in seven units.

2. Saskatchewan Power Corporation
   (a) Coteau Creek site, South Saskatchewan River: The Corporation plans to install hydro-electric facilities at the earth-fill dam which the Prairie Farm Rehabilitation Administration is currently constructing as an aid to irrigation. Initially, the hydro-electric development is expected to consist of three units of 50,000 or 60,000 hp. each. Two similar units will be added at a later date. The overall project is scheduled for completion in 1966.
   (b) Squaw Rapids, Saskatchewan River: Construction was begun for the installation of six units at 46,000 hp. each. Four units are planned for service by 1963 and the remaining two by 1964.

Manitoba

1. Manitoba Hydro-Electric Board
   Kelsey Generating Station, Nelson River: Construction was continued for the installation of five units of 42,000 hp. each. Two units are to be in operation by 1 July 1960 and three others by 31 December 1960. Provision is being made for a sixth similar unit.

Ontario

1. Hydro-Electric Power Commission of Ontario
   (a) Robert H. Saunders - St. Lawrence Generating Station, St. Lawrence River: Completed in 1959 with the installation of seven units of 75,000 hp. each, increasing to 1,200,000 hp. the total installed capacity in the Canadian plant.
   (b) Abitibi Canyon, Abitibi River: Completed in April 1959 with the installation of a fifth unit of 66,000 hp.
   (c) Silver Falls, Kaministikwia River: Completed in September 1959 with the installation of a single unit of 60,000 hp.
   (d) Red Rock Falls, Mississagi River: Construction was continued for the installation of two units of 26,500 hp. each. The first unit is scheduled for service in December 1960.
   (e) Otter Rapids, Abitibi River: Construction was continued for the installation of four units of 60,000 hp. each, with minimum provision being made for the addition of four other units. Two units are scheduled for service in 1961.
2. Great Lakes Power Company
   Cat Falls, Michipicoten River: Completed in August 1959 with the installation of a single unit of 30,300 hp.

Quebec

1. Quebec Hydro-Electric Commission
   (a) Bersimis II, Bersimis River: Construction was proceeding for the installation of five units of 171,000 hp. each. Three units were placed in service during 1959. The remaining two units are scheduled for completion by 1 October 1960.
   (b) Beauharnois, St. Lawrence River: Construction was continued on the third and final section of the power house to contain eleven units of 73,700 hp. each. Operation of the third section commenced in 1959 with the installation of four units totalling 294,800 hp. The remaining units are to be installed at intervals of 2-1/2 months and by 1961, the entire plant with a total rated capacity of 2,234,700 hp. will have been completed.
   (c) Carillon, Ottawa River: Construction was begun for the installation of fourteen units each rated at 60,000 hp.

2. Aluminum Company of Canada Limited
   (a) Chute des Passes, Peribonka River: Construction was continued for the installation of five units at 200,000 each. Three units were placed in operation during 1959 with completion of the project expected in February 1960. Work will be resumed in the spring of 1960 to permit the diversion of Manouan Lake into the Bonnard River, a tributary of the Peribonka River above Passe Dangereuse.
3. James Maclaren Company Limited
   Dufferin Falls, Lievre River: Completed in February 1959 with the installation of two units of 25,000 hp. each.
4. Quebec Cartier Mining Company
   Hart Jaune River: Construction was continued for the installation of three units at 22,000 hp. each. The three units are expected to be placed in service during the period September to November 1960.
5. Quebec Department of Hydraulic Resources
   Water power investigations were continued on the Broadback, Rupert, Eastmain, Great Whale and Fort George Rivers in the James Bay watershed; on the Kaniapiskau River in the Ungava Bay watershed; on the Mistassibi and Mistassini Rivers in the Lake St. John watershed and the Moisie, Sault-au-Cochon, Sault-au-Mouton, Portneuf and Escoumains Rivers on the North Shore of the Lower St. Lawrence River.

New Brunswick

1. New Brunswick Electric Power Commission
   (a) Grand Falls Generating Station, Saint John River: The Commission acquired this plant from the Gatineau Power Company on 1 May 1959.
   (b) Milltown, St. Croix River: A reconditioned 500-hp. unit originally installed in 1910 and retired in 1920 was again placed in service 17 June 1959.

Nova Scotia

1. Nova Scotia Power Commission
   (a) Sissiboo Falls, Sissiboo River: Construction was continued on a single-unit 8,000-hp. installation, scheduled for completion in March 1960.
   (b) Weymouth Falls, Sissiboo River: Construction was continued on a single-unit 12,000-hp. installation, scheduled for completion in July 1960.
   (c) Developments at Riverdale on the Sissiboo River and at Wreck Cove on Wreck Cove Brook are in active prospect with proposed installations of 10,800 hp. and 90,000 hp. respectively.
2. Nova Scotia Light and Power Company Limited
   (a) Lequille, Lequille River: Construction was begun of a single-unit 7,500-hp. development for completion in 1961.
   (b) A single-unit 6,500-hp. development at Alpena on the Nictaux River is in active prospect with date of completion expected in 1962.

Newfoundland

1. United Towns Electric Company Limited
   (a) Pitmans Pond, New Chelsea Brook: Completed in November 1959 with the installation of a single 1,200-hp. unit.
   (b) Heart's Content, Heart's Content River: Installation of a single unit of about 3,200 hp. is proceeding and is scheduled for completion in June 1960. The single unit will replace the existing two-unit plant.

2. Iron Ore Company of Canada
   Menihek Rapids, Ashuanipi River, Labrador: Construction was underway to double the existing plant capacity by the addition of a 12,000-hp. unit. The new unit is expected to be in service in April 1960.
3. Newfoundland Light and Power Company Limited
   Middle Brook near Gambo: Installation of a single-unit 6,500-hp. development is in active prospect.
4. Southern Newfoundland Power and Development Limited
   Bay d'Espoir: Installation of two 38,500-hp. units is in active prospect as part of an ultimate development of 350,000 hp.
5. Hamilton Falls Power Corporation Limited
   Scott Falls, Unknown River, Labrador: Installation of two 25,000-hp. units is in active prospect as part of an ultimate development of 300,000 hp. This development on a tributary of the Hamilton River is one of three subsidiary projects which may be built prior to construction of the main features included in the plan for Hamilton River development.

Yukon and Northwest Territories

1. Northern Canada Power Commission
   Snare Falls, Snare River N.W.T.: Construction has continued on installation of a single 9,200-hp. unit with provision for a second similar unit. The first unit is scheduled for operation by November 1960.

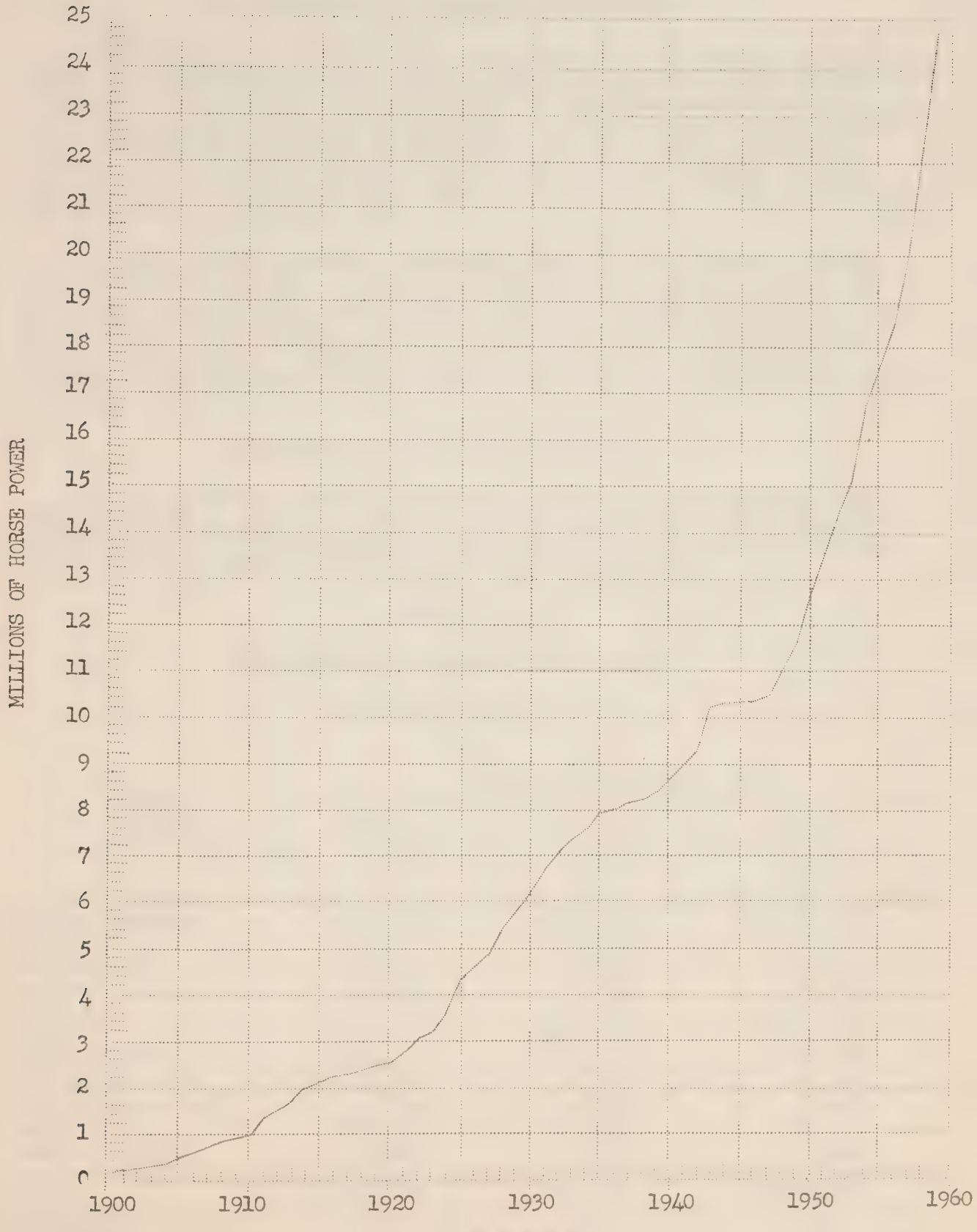
GROWTH OF WATER POWER DEVELOPMENT

Since the inception of long-distance transmission of electricity near the beginning of the present century, water power development in Canada has undergone a remarkable growth, the total installation of 177,323 hp. at the end of the year 1900 being insignificant in comparison with the 24,888,426 hp. installed by the end of 1959. The rapid and continuous growth in installed capacity is illustrated in the diagram on the following page which shows the total installation in millions of horse power at the end of each year, 1900 to 1959. The installed capacity of the Province of Newfoundland has been included in the total for Canada from 1949 forward.

During the present century, the rate of growth in the total capacity of water power installations in Canada has tended to accelerate. The average annual increase of 56,000 hp. in the period 1900-1905 was stepped up sharply in subsequent years, owing largely to improvements in electrical transmission and to the building by utilities of large hydro-electric stations. During the period 1906-1922, development proceeded at a fairly uniform rate of 150,000 hp. per year. As a result of the heavier demand for electricity during the prosperous 1920's, the rate of installation increased appreciably in 1923 and continued at a nearly uniform rate of 377,000 hp. per year for the period 1923-1935. As large-scale hydro-electric projects require a long construction period, their completion tends to lag behind the demand for electric power which responds quickly to general economic conditions. This time lag is evident when the demand for power fell off during the early 1930's: Projects under way were completed but the economic depression resulted in a low rate of installation during the years 1936-1939. The great demand for power for war purposes accounts for the high average rate of increase of 481,000 hp. per year during the period 1940-1943. Few developments were undertaken in the later war years or in the immediate post-war period, so that only a small amount of new capacity came into operation from 1944 to 1947 inclusive. However, the results of the later post-war program of construction are apparent in the

TOTAL WATER POWER INSTALLATION IN CANADA

1900-1959



amount of growth during the twelve-year period 1948 to 1959 inclusive when the average rate was nearly 1,200,000 hp. per year. Present programs of expansion indicate a continuation of this rate of growth for several years.

COAL EQUIVALENT OF DEVELOPED WATER POWER

Apart from its production from water power, electric energy in large amounts is produced by thermal plants. Coal, oil and natural gas are the principal fuels, although the greater part of the total thermal-electric generation is derived at present from steam plants which burn coal. Hence, the importance of water power in the economy of power production may be represented by the amount of coal which would have been consumed if steam had been used to produce the total amount of power realized from hydro-electric and hydraulic sources during 1959.

The total energy generated from water power in Canada during 1959 was about 96,516,000,000 kwh. Assuming that one pound of coal rated at 12,000 B.T.U. per pound is required to produce one kilowatt-hour of electricity by thermal-electric generation, the total 1959 water power output is equivalent to the burning of over 48,250,000 tons of such coal, which would be in addition to the estimated 1959 consumption of about 24,000,000 tons including all types of coal.

UTILIZATION OF DEVELOPED WATER POWER

For the purpose of showing the general manner in which developed water power in Canada is utilized, Table II lists the hydraulic installation of each province and of the territories under two divisions, namely "Utilities" and "Industries" which are discussed on the following pages.

TABLE II

DISTRIBUTION OF DEVELOPED WATER POWER

At End of Year 1959

Province or Territory	Turbine Installation - hp.		
	Utilities	Industries	Total
1	2	3	4
British Columbia	1,711,887	1,797,573	3,509,460
Alberta	311,530	1,065	312,595
Saskatchewan	125,500	3,335	128,835
Manitoba	763,000	15,900	778,900
Ontario	7,503,310	478,841	7,982,151
Quebec	8,110,678	3,204,729	11,315,407
New Brunswick	227,945	26,930	254,875
Nova Scotia	168,375	14,793	183,168
Prince Edward Is.	240	1,420	1,660
Newfoundland	269,015	101,120	370,135
Yukon and N.W.T.	31,540	19,700	51,240
Canada	19,223,020	5,665,406	24,888,426
Percentage	77	23	100

In the above table, Column 2 includes only hydro-electric stations which develop power mainly for sale. Column 3 includes only water power developed directly by industries mainly for their own use. Column 4 includes all hydraulic turbines and water wheels installed in Canada.

Utilities

The classification "Utilities", listed in Column 2 of the preceding table covers companies, municipalities or individuals who sell most of the power they develop. In some instances they include also certain subsidiary companies whose main purpose is to develop and sell power to a parent company for industrial purposes. Installations of utilities totalling 19,223,020 hp. represent 77 per cent of Canada's total developed water power as at 31 December 1959.

In recent years, the majority of new hydraulic developments have been of the utility type; even hydro-electric plants built mainly for the operation of some special industry serve to some extent as a utility by supplying the local domestic needs or in selling surplus power, thus assuring the maximum economic development of the site. Growing demand in industrial, commercial, and domestic loads indicates further expansion in the field of the utility station and the current need for the new developments now under construction or planned.

Industries

The classification "Industries" in Column 3 of Table II includes those companies or individuals which develop power mainly for their own use. While the figures indicate that industries have developed only 23 per cent of Canada's total installed water power capacity, it must be emphasized that in addition to the power generated in their own plants, industries purchase large amounts of power from utilities. For example, of the total of 28,848 million kilowatt-hours of electric energy made available in 1958 by the Hydro-Electric Power Commission of Ontario, about 29 per cent was sold direct to industrial customers. The importance of water power in the pulp and paper industry and in the mineral industry, the largest users of this source of energy, is discussed in the following.

The pulp and paper industry, which operated at below rated capacity during 1959, is one of the world's great industrial enterprises. In 1958, Canada's total mill capacity for the production of newsprint paper was about seven million tons per year which is much greater than that of any other country; (in the production of wood pulp, Canada is second only to the United States). About 94 per cent of the manufactured newsprint is exported making the industry a particularly important contributor to Canada's export trade balance.

The pulp and paper industry is a major industrial user of water power in Canada, its electric consumption representing about 18 per cent of the total electric energy produced in Canada. In 1958 the industry generated about 4,745 million kwh. for its own use and purchased an additional 13,870 million kwh. Most of the total of 18,615 million kwh. purchased or generated was produced by water power.

The relationship between the pulp and paper industry and water power development is an intimate one in that each contributes substantially to the other's expansion. The manufacture of newsprint requires a mechanical installation of about 100 hp. for each ton of daily output; hence, an ample supply of power at reasonable cost is essential to the industry.

In the mineral industry, although only a small number of water power plants are used directly to serve mining operations, smelting and refining operations require large amounts of hydro-electricity. In 1958 the mineral industry consumed about 22,939 million kwh. of electric energy representing about 22 per cent of the total generated in Canada. Of the total consumed more than 16,100 million kwh. were utilized in smelting and refining of metals. Most of this amount was used for the production of aluminum. While Canada has no known deposits of bauxite, the availability of low-cost hydro-electric power has fostered the establishment of an aluminum industry which produces one-quarter of the world's supply of this metal.

The incidence of large water power resources in those regions of Canada in which the more important mineral discoveries have been made has greatly facilitated mining development. Metal mining, which forms an important part of the mining industry in Canada, is carried on mainly in two principal physiographic regions: The western Cordillera and the Canadian Shield. The topography and precipitation of the mountainous regions are favourable to water power development which provides power for mining and smelting operations. The Canadian Shield, a Precambrian formation in which many important metaliferous ores are found, forms a wide arc around Hudson Bay; the region has been heavily glaciated in recent geological times so that its river systems are comparatively young and are characterized by numerous lakes joined by short sections of rapids and falls which frequently afford water power sites which are conducive to economic mining operations. The value of water power to mining operations is evident in Canada's asbestos industry which depends almost exclusively upon hydro-electric power and which produced about 50 per cent of the world's supply in 1959.

DEVELOPED WATER POWER IN RELATION TO POPULATION

The following Tables III and IV show Canada's developed water power in relation to population. Table III lists the estimated population of each province and of the territories on 1 January 1960 in comparison with the installed capacity of existing water power developments. Table IV lists the provinces and the territories in their order of magnitude with respect to population, total water power installation and per capita installation.

The figures listed for installation per thousand population in the provinces and territories reflect in part the extent and character of the utilization of water power in each. The average for the whole country is 1,410 hp. per thousand population, a factor which places Canada in an outstanding position with respect to water power development and, on this basis, second only to Norway among countries of the world. On the basis of available information, Canada is exceeded only by the United States of America in total water power installation.

TABLE III

Province or Territory	Installed Capacity - hp. 31 Dec. 1959	Estimated Population 31 Dec. 1959	Installation per thousand population hp.
British Columbia	3,509,460	1,592,000	2,204
Alberta	312,595	1,264,000	247
Saskatchewan	128,835	907,000	142
Manitoba	778,900	892,000	873
Ontario	7,982,151	6,029,000	1,324
Quebec	11,315,407	5,062,000	2,235
New Brunswick	254,875	595,000	428
Nova Scotia	183,168	719,000	255
Prince Edward Is.	1,660	103,000	16
Newfoundland	370,135	453,000	817
Yukon and N.W.T.	51,240	34,000	1,507
Canada	24,888,426	17,650,000	1,410

TABLE IV

Order of Magnitude:	Provinces and Territories in their order of magnitude with respect to: Population	Total Water Power Installation	Per Capita Installation
First	Ontario	Quebec	Quebec
Second	Quebec	Ontario	British Columbia
Third	British Columbia	British Columbia	Yukon and N.W.T.
Fourth	Alberta	Manitoba	Ontario
Fifth	Saskatchewan	Newfoundland	Manitoba
Sixth	Manitoba	Alberta	Newfoundland
Seventh	Nova Scotia	New Brunswick	New Brunswick
Eighth	New Brunswick	Nova Scotia	Nova Scotia
Ninth	Newfoundland	Saskatchewan	Alberta
Tenth	Prince Edward Is.	Yukon and N.W.T.	Saskatchewan
Eleventh	Yukon and N.W.T.	Prince Edward Is.	Prince Edward Is.

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

WATER RESOURCES BRANCH

WATER POWER RESOURCES OF CANADA

BULLETIN No. 2721

15 March 1961
OTTAWA

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DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

WATER RESOURCES BRANCH

WATER POWER RESOURCES OF CANADA

The Water Resources Branch, Department of Northern Affairs and National Resources, presents its annual review of the water power resources of Canada and of their development to the end of 1960. Based upon the Branch's water power inventory, resources are summarized and such salient features as provincial and territorial distribution, current progress of construction, rate of development, and industrial utilization are discussed briefly.

One of the most important factors influencing Canada's economic development has been the availability of large quantities of low-cost electric power derived from the nation's water power resources. Since early in the present century, water power has increased Canada's productive capacity at a remarkable rate. In less than fifty years, an economy which was essentially agricultural and which produced mainly raw materials for export has changed to one increasingly dependent upon industrial operations. This transition, coincident with the growth of water power development, has been accelerating in recent years. The close relationship between water power and industry in Canada is particularly evident in southern Quebec and Ontario which, although lacking in indigenous coal, have become the most highly industrialized regions of the country through the use of their large water power resources. The Province of British Columbia, which is rich in potential water power, also has been making rapid industrial progress in step with water power development. Most of the current power demand in Canada is provided by hydro-electric developments and during 1960 the net increase in installed hydro-electric capacity amounted to 1,741,820 hp. Considerable additional hydro-electric capacity is currently under construction for initial operation during the next few years. In some areas of the country, however, there is a growing tendency towards increased thermal-electric generation, a tendency which reflects not only a stage of hydro-electric development wherein most of the sites located within economic transmission distance of established demand areas have already been developed, but also an increasing awareness of the benefits of resource conservation which may be derived through the operation of integrated power systems supplied by both hydro-electric and thermal-electric plants.

Copies of this annual bulletin may be obtained free of charge from the Director, Water Resources Branch, Department of Northern Affairs and National Resources, Ottawa.

TOTAL AVAILABLE AND DEVELOPED WATER POWER

Table I lists by province and territory the total water power resources of Canada and the present total capacity of all water power plants in the country, determined from the records of the Water Resources Branch. The Branch, under agreements with provincial authorities, carried out hydrometric investigations on rivers throughout the country and maintains continuous records of stream flow which are accumulated from all sources. The estimates of available power are revised as stream-flow records for longer periods accumulate and as more detailed information on potential power sites is obtained. As defined on the following pages, estimates are made on the bases of ordinary minimum flow and dependable maximum (ordinary six-months) flow. In the gathering of information on developed water power and power output, close liaison is maintained with the Dominion Bureau of Statistics. The totals of installed capacity are based upon the manufacturer's rating of each turbine and water wheel, where this information is available.

TABLE I

AVAILABLE AND DEVELOPED WATER POWER IN CANADA

At End of Year 1960

Province or Territory	Available continuous power at 80% efficiency - hp.		Installed Turbine Capacity hp.
	At Ordinary Min. Flow	At Ordinary 6-Months Flow	
1	2	3	4
British Columbia	18,200,000*	19,400,000*	3,700,326
Alberta	911,000	2,453,000	414,455
Saskatchewan	550,000	1,120,000	132,135
Manitoba	3,492,000	5,798,000	988,900
Ontario	5,496,000	7,701,000	7,814,562
Quebec	10,896,000**	20,445,000**	12,440,145
New Brunswick	123,000	334,000	254,258
Nova Scotia	30,500	177,000	184,538
Prince Edward Island	500	3,000	1,660
Newfoundland	1,608,000	3,264,000	384,025
Yukon Territory	4,678,000*	4,700,000*	38,190
Northwest Territories	374,000	808,000	22,250
Canada	46,359,000*	66,203,000*	26,375,444***

* These figures reflect the effect of possible stream flow regulation based on known storage potentials.

** These figures undoubtedly will be revised substantially upon completion of a review of water power resources now being carried out by the Quebec Department of Hydraulic Resources with the co-operation of the Water Resources Branch.

**** During the past year, a major review of the Branch inventory of installed water power capacity in Canada was carried out, resulting in a net reduction of approximately one per cent in the total capacity listed previously.

Columns 2 and 3 in the above table do not include the power potential of major river diversions that have been investigated but not developed; for example, in the Province of British Columbia, the potential of the Chilko River itself has been included, but not the potential of the Chilko-Homathko River diversion which some publications quote as 1,000,000 hp. A number of other major diversion possibilities exist, particularly in British Columbia where topographical conditions favour such rearrangements of flow. The addition of the power potential of these major diversions to the available power figures given in the preceding table may be necessary in some instances to reconcile these figures with those obtained from other sources.

Column 2 lists the estimated continuous power ordinarily available at periods of low discharge under existing conditions of river flow; the "Ordinary Minimum Flow" is based upon the average of the mean flows for the two lowest periods of seven consecutive days in each year covered by the period of record. Estimates of dependable maximum power as given in Column 3 are based upon the "Ordinary Six-Months Flow", which is the computed dependable stream flow usually available for at least six months in the year under existing flow conditions. On rivers for which there are no specific discharge records, estimates of flow are made from all available pertinent information relating to runoff in the area.

In the case of hydraulic head, the figures of Columns 2 and 3 are based upon the actual drop, or feasible concentration of head, which has been measured or at least carefully estimated at existing falls, rapids and known power sites; no consideration has been given to possible economic concentrations of head on rivers and streams of gradual gradient, except at those locations where the feasible head has been definitely established by field investigations. Many unrecorded power sites exist on rivers and streams throughout the country, particularly in the less explored northerly districts, but these cannot be included in the tabulation until more detailed survey work has been made. Thus, for both the total number of sites and the possible head at each site, the listed figures of available power represent only the minimum water power possibilities of Canada.

The figures for installed turbine capacity, listed in Column 4, are the totals of plant capacities based upon the manufacturer's rating as indicated on the name-plate of each unit. In exceptional instances where, subsequent to the initial development, a change in the normal operating head has been effected, a rating based on the new normal operating head is used. While the maximum economic turbine installation at any power site can be determined only by careful consideration of all conditions and circumstances pertinent to its individual development, it is the usual practice to install turbines which have a total capacity in excess of the power equivalent of the ordinary six-months flow at the site. This additional capacity may be installed for use at peak-load hours or to take advantage of periods of high river flow, or to facilitate plant maintenance. In some instances, subsequent

to initial development, storage dams have been built to provide more uniform river flows. In others, deficiencies in power output during periods of low flow have been offset by auxiliary power from thermal-electric plants or by interconnection with other hydro-electric plants which operate under different load conditions or are located on other rivers with different flow characteristics.

The extent to which the installed capacity exceeds the power equivalent of the ordinary six-months flow is dependent upon the factors which govern the system of power plant operation, and varies widely in different areas of the country. In some individual developments the difference may amount to as much as several hundred per cent. For this reason the figures in Column 4 are not directly comparable with those in Column 3. In view of the trend to provide installed capacity often far in excess of the potential at ordinary six-months flow, it is no longer feasible to offer reliable estimates of future capacity installation based upon estimates of available water power.

Although extensive use is being made of Canada's water power resources at the present time, many large potential power sites in various parts of the country have yet to be developed. In some areas, where the more attractive sites within economic transmission distances of present centres of population have already been developed, the expansion of thermal-electric development is necessary to satisfy the increasing power demand. In other areas, reserves of accessible power continue to meet the growing power requirements of many of the more densely settled areas. In addition, improvements in the techniques of long-distance transmission, including the use of higher voltages, are bringing more and more sites within the orbit of existing systems. In the more remote districts, water power will make possible the utilization of mineral and other resources and promote the establishment of new communities. There can be no doubt that the existence in northern regions of large quantities of potential water power will prove to be a factor of the utmost significance in the eventual realization of the natural wealth of Canada's North.

PROVINCIAL AND TERRITORIAL DISTRIBUTION OF WATER POWER

Table I on page 2 shows the provincial and territorial distribution of Canada's available and developed water power. A review of this table illustrates the fact that considerable amounts of water power are being used in all provinces except Prince Edward Island where resources are small. As the development of Canada's natural resources proceeds, the fortunate incidence of water power in proximity to mineral deposits, pulpwood, and other natural resources becomes more apparent.

British Columbia, traversed by three distinct mountain ranges and with, on the whole, a high rate of precipitation, has many mountain rivers which offer opportunity for power development. The province ranks second in presently recorded available resources and is exceeded only by Quebec and Ontario in installed capacity. Considerable power potential exists principally on such rivers as the Columbia, Fraser, Peace and the Stikine. A large part of the present development, however, is located in the southern portion of the province. The Aluminum Company of Canada's Kemano plant, with a present

capacity of 1,050,000 hp., is the largest single development in British Columbia. The British Columbia Electric Company Limited is the major hydro-electric producer and distributor in the province. The British Columbia Power Commission, which was organized in 1945, also has become an important power producing and distributing agency.

In Alberta, the principal hydro-electric developments from which Calgary Power Limited serves a large part of the southern portion of the province, are located on the Bow River and its tributaries. A substantial share of the water power resources is located in the northern region of the province, rather remote from present centres of population. Coal, oil and natural gas, of which there are large reserves located in the province, supply a very substantial portion of its electric power requirements.

In Saskatchewan, abundant water power resources are located in the central and northern parts of the province, principally on the Churchill, Fond du Lac, and Saskatchewan Rivers. Existing water power developments are confined to mining uses in the northern areas; however, new developments, now under construction on the Saskatchewan River, will be tied into the transmission network of the Saskatchewan Power Corporation of the Provincial Government which serves the more settled areas of the province and which at present is supplied exclusively by thermal-electric plants. As in Alberta, coal, oil and natural gas, of which there are substantial reserves located in the province, supply much of its electric power requirements.

Of the Prairie Provinces, Manitoba has the largest water power resources, there being great potential power on the Churchill, Nelson, and Saskatchewan Rivers. The larger present developments are located on the Winnipeg River, now fully developed, and serve Winnipeg, adjacent municipalities, and the transmission network of the Manitoba Power Commission. Increasing amounts of electric power are currently needed to meet the growing power demands of the southern part of the province; however, this need will be met temporarily by hydro-electric power from a development on the Saskatchewan River, expected to begin operation in 1964.

Ontario has large water power resources, being exceeded in this respect only by Quebec and British Columbia. It has developed the greater part of its estimated available power and ranks second in water power development among the provinces. The Hydro-Electric Power Commission of Ontario is the greatest power-producing and distributing organization in Canada and operates 70 hydro-electric generating stations with a total installed capacity of approximately 7,000,000 hp. and two thermal-electric stations with a combined generating capacity of nearly 1,200,000 kw. Its largest water power development is located on the Niagara River at Queenston where the total capacity of the Sir Adam Beck-Niagara Generating Stations Nos. 1 and 2 and associated pumping-generating station is 2,521,000 hp. The Commission also purchases large amounts of electric power generated outside the province, mainly in Quebec.

The Province of Quebec is the richest in water power resources, with more than 30 per cent of the total recorded for Canada. Quebec also ranks highest in developed power, its present installation of 12,440,145 hp. being about 47 per cent of the total for all provinces. The largest single hydro-electric installation in Canada is the Quebec Hydro-Electric Commission's

Beauharnois development on the St. Lawrence River with a capacity of 2,087,300 hp. installed to date. Also notable are the Commission's Bersimis I development on the Bersimis River with an installed capacity of 1,200,000 hp. and the Shipshaw plant of the Aluminum Company of Canada Limited on the Saguenay River which is rated at 1,140,000 hp. A scheme which will represent a major step forward in the development of Quebec's hydro-electric resources was announced in mid-1960 by the Quebec Hydro-Electric Commission. This scheme, involving harnessing of the headwaters of the Manicouagan and Outardes Rivers, will eventually produce nearly 6,000,000 hp. of new capacity at new and existing developments on the two rivers. Power production in the province is greatly facilitated by the regulation of stream flow by the Quebec Department of Hydraulic Resources through the storage dams it operates or controls.

The water power resources of New Brunswick and Nova Scotia, although small in comparison with those of other provinces, constitute a valuable source of power of which considerable use is being made. Both provinces have numerous rivers upon which moderate-sized power sites exist within economic transmission distance of the principal cities and towns; other sites are advantageously situated for use in development of the timber and mineral resources. These provinces also are favoured with abundant indigenous coal supplies. In Prince Edward Island, there are no large streams and consequently water power sites are limited in size to those used for small mills.

On the basis of the limited stream flow data available, Newfoundland's water power resources are estimated to be of considerable magnitude. On the Island, despite the fact that, in general, the length of the rivers is not great, topography and runoff conditions favour the development of power; in Labrador, the power potential of the Hamilton River is such as to permit its classification as one of the largest undeveloped sources of water power in Canada. Considerable development has taken place on the Island, the larger developments having been constructed to serve the pulp and paper industry.

The two Territories which comprise Canada's vast northland possess extensive water power resources. In the Yukon Territory, most of the resources are located on the Yukon River and its tributaries. There exists also the possibility of diverting the headwaters of the Yukon River through the Coast Mountains to utilize a high head near tidewater in northern British Columbia; such a development would, however, affect adversely the power potential of the Yukon River in the Yukon Territory. In the Northwest Territories, resources are of considerable magnitude. Extensive water power resources exist on rivers flowing into Great Slave Lake. Of major significance is the hydro-electric potential existing on the South Nahanni River, which drains to the Mackenzie River via the Liard River. On the basis of preliminary investigations, it is estimated that, with total regulation and complete utilization of the total head susceptible of development, the hydro-electric potential of the South Nahanni River could exceed one million continuous horsepower. Future listings of available continuous power for the Northwest Territories will reflect the major power potential of the South Nahanni River when further studies permit a more accurate assessment of its resources. Indications are that the rivers draining the Keewatin District, lying north of Manitoba, will contribute materially to the total power potential of the Northwest Territories. Power supply from present developments is used exclusively to satisfy the needs of local mines and adjacent settlements. Due to the lack of developed native fuel sources and to transportation difficulties, water power is of special importance in the development of mining areas such as Yellowknife in the Northwest Territories, and Mayo in the Yukon Territory.

To encourage the development of the resources of northern Canada, the Federal Government established in 1948 an agency, now known as the Northern Canada Power Commission, for the construction and management of public utility plants. The Deputy Minister of Northern Affairs and National Resources is Chairman of this Commission and the Director of the Water Resources Branch is a Member.

PROGRESS IN DEVELOPMENT DURING 1960

The total of 1,741,820 hp. of new capacity installed during 1960, while falling short of the record total of 2,508,800 hp. installed in the previous year, nevertheless represents a significant addition to Canada's hydro-electric generating capacity. Construction at present under way is expected to yield approximately 243,000 hp. of new capacity in 1961 and an additional 4,500,000 hp. of new capacity within the next few years, with provision made for a further 1,000,000 hp. as required in subsequent years.

A detailed review of new and prospective developments was given in the Branch's Bulletin No. 2720 "Progress in Electrical Generation in Canada - 1960" which was issued on 2 January 1961. Copies of this bulletin are still available, free of charge, upon request. The following is a brief list of hydro-electric developments completed or under construction during 1960, or proposed for initial construction within the next few years:

British Columbia

1. British Columbia Power Commission
   (a) Kokish River development on Vancouver Island: In the planning stage only. A total installation of 51,500 hp. is expected.
   (b) Pyramid Mountain-Murtle River: In the planning stage only. Initial development will consist of one 43,000-hp. unit with ultimate development expected to reach 172,000 hp. in four units.
2. British Columbia Electric Company Limited
   Bridge River No. 2: Total development was realized in 1960 following completion of Mission Dam and installation of the remaining two units in the powerhouse. The development now has a total installed capacity of 328,000 hp. in four equal units. The increased head due to construction of the Mission Dam, will increase the total turbine capacity at Bridge River No. 1 Powerhouse from 248,000 hp. to 276,000 hp.
3. City of Revelstoke
   Cranberry Creek: The initial phase of this development was completed with installation of one 5,800-hp. unit. One similar unit to complete the development will be installed when necessitated by demand increase.
4. Northern British Columbia Power Company Limited
   Falls River, Big Falls Creek: In November, installation of a second 6,000-hp. unit was completed, bringing the total installed capacity to 12,000 hp.
5. Peace River Development Company
   Peace River above Hudson Hope: Planning of this project was continued. Preliminary plans indicate that the project will consist in part of a main storage dam where hydro-electric facilities under a maximum operating head of 600 feet will provide a generating capacity of about 2,500,000 kw. A second dam and hydro-electric plant is expected to be developed downstream from the main dam.

6. Northwest Power Industries Limited

An active interest was maintained in the Yukon power project in Yukon Territory and in the Nass River project in northern British Columbia. Surveys made in previous years have been brought up to the design stage and no further work is contemplated for the present.

7. Columbia River

Negotiations between Canada and the United States led, early in 1961, to the signing of a treaty relating to the development of the Columbia River in Canada. Ratification of the treaty would permit the commencement of work on the development of storage in Canada for the benefit of plants in the United States. Under the terms of the agreement, Canada would receive one-half of the power benefits accruing to the United States from the regulation of 15.5 million acre-feet of storage, and one-half of the value of the estimated flood damage prevented in the United States through flood control operation of these projects. It is estimated that Canada's initial share of the power benefits will approximate 6,750,000,000 kilowatt-hours of annual energy from 1,300,000 kw. of dependable capacity.

Alberta

1. Calgary Power Limited

(a) Spray and Rundle, Bow River: Total development was reached in 1960 at both plants. Capacity of the Spray plant was doubled with the addition of one 62,000-hp. unit. One 40,000-hp. unit was installed in the Rundle plant to raise the total capacity to 63,000 hp.

(b) Brazeau River: Construction was continued for the installation late in 1964 of a single 200,000-hp. unit at Big Bend, about 15 miles upstream from the confluence with the North Saskatchewan River. While a total development of up to 800,000 hp. has been proposed, no final decision has yet been made with regard to future development.

(c) North Saskatchewan River: Investigations were continued for a hydro-electric development at the Brazeau Forks site, located below the confluence with the Brazeau River.

Saskatchewan

1. Consolidated Mining and Smelting Company

Wellington Lake, Charlot River: Total development was realized in 1960 on installation of a second 3,300-hp. unit.

2. Eldorado Mining and Refining Limited

Waterloo Lake, Charlot River: Construction was commenced for the installation of a single-unit 10,000-hp. plant.

3. Saskatchewan Power Corporation

(a) Coteau Creek site, South Saskatchewan River: Construction continued on the South Saskatchewan River Project, being developed by the Prairie Farm Rehabilitation Administration primarily for irrigation purposes. Associated power facilities will be incorporated at the main dam by the Saskatchewan Power Corporation, which plans an initial installation of three units of about 60,000 hp. each, and provision for two additional units to bring the ultimate capacity of the development to 300,000 hp.

(b) Squaw Rapids, Saskatchewan River: Construction continued on this project which, when completed, will comprise six units of 46,000 hp. each. Installation of four of the units is planned for 1963, and the remaining two for 1964.

Manitoba

1. Manitoba Hydro-Electric Board
   (a) Kelsey Generating Station, Nelson River: Initial operation commenced in 1960 when five units of 42,000 hp. each, were placed in service. Provision has been made for a sixth unit of the same rating when the increase in demand warrants its installation.
   (b) Grand Rapids, Saskatchewan River: Construction was commenced on an initial installation of 450,000 hp. in three units of 150,000 hp. each. Two units are scheduled for service late in 1964, and a third unit for 1965.

Ontario

The Hydro-Electric Power Commission of Ontario
   (a) Red Rock Falls, Mississagi River: Construction was virtually completed in 1960 when one of two 26,500-hp. units was placed in operation. The second unit is expected to be in service early in 1961.
   (b) Otter Rapids, Abitibi River: Rapid progress was made for an initial installation of four units, each of 60,000 hp. The control structure at the site will, however, provide for an ultimate installation of eight units with a total installed capacity of 480,000 hp. Two units are scheduled for operation late in 1961 and two others in 1963.
   (c) Little Long, Harmon, and Kipling, Mattagami River: The three plants will be located on a 12-mile reach of the river in the general location of the existing Smoky Falls hydro-electric station. While engineering design for the three stations was only in a preliminary stage, initial construction was under way at the Little Long plant where two 84,000-hp. units are tentatively scheduled for service in 1963, with provision made for two similar units. The Harmon and Kipling plants are expected to begin service in 1965 and 1966 respectively, and initially will each comprise three units of 63,000 hp. Ultimate installation is expected to provide a total turbine capacity of 378,000 hp. in six units at the Harmon plant and 441,000 hp. in seven units at the Kipling plant.

Quebec

1. Quebec Hydro-Electric Commission
   (a) Bersimis II, Bersimis River: Ultimate development was reached with the installation of two units of 171,000 hp. each, bringing the total capacity to 855,000 hp. in five units.
   (b) Beauharnois, St. Lawrence River: The third and final phase of development was brought nearer completion with the addition of five units of 73,700 hp. each, raising to nine the total of units installed during this phase. The tenth unit is scheduled for operation early in 1961, and provision is being made for an eleventh and final unit. Installation of the last two units will bring the total installed capacity of the entire Beauharnois development to 2,234,700 hp. in thirty-nine units.

(c) Carillon, Ottawa River: Construction was continued for the installation of 840,000 hp. in fourteen units. Operation of the first unit is planned for the fall of 1962 and the remaining units during the 1962-1965 period.

(d) Manicouagan and Outardes Rivers: Plans were announced in the summer of 1960 for a project involving the harnessing of the headwaters of these rivers to provide nearly 6,000,000 hp. of new capacity at new and existing developments on both rivers. Development of three sites on the Manicouagan River will realize some 3,700,000 hp. and two sites on the Outardes River an additional 1,440,000 hp. Regulation from upstream reservoirs will benefit the Manicouagan Power Company's McCormick Dam Project by permitting a capacity increase from the present 292,400 hp. to about 580,000 hp., and Quebec North Shore Paper Company's Outardes Falls plant from 70,600 hp. to 410,000 hp.

2. Aluminum Company of Canada

Chute des Passes, Peribonka River: Early in 1960, the last two units of a total of five were placed in service, bringing the total installed capacity of the plant to 1,000,000 hp. Work was completed on the Bonnard River - Lake Manouan diversion, permitting the stored waters of Lake Manouan to be diverted into the Bonnard River, a tributary of the Peribonka River above Passe Dangereuse.

3. Quebec Cartier Mining Company

Hart Jaune River: Construction was completed on the installation of three units of 22,000 hp. each. The powerhouse, located 27 miles upstream from Big Manicouagan Lake, will operate by remote control.

4. Office de l'Electrification Rurale

Magpie River near Magpie Village: Construction commenced on this plant, designed to house two units of 1,500 hp. each.

5. Quebec Department of Hydraulic Resources

Water power investigations were continued on the Eastmain, Fort George, Great Whale, and Nastapoca Rivers in the Hudson Bay watershed, on the Kaniapiskau, Whale, and George Rivers in the Ungava Bay watershed, on the Chamouchouane, Mistassini, and Mistassibi Rivers in the Lake St. John watershed, and the Moisie, Marguerite, Portneuf, Sault-au-Mouton, and Escoumains Rivers on the north shore of the lower St. Lawrence River.

New Brunswick

No new hydro-electric capacity was brought into operation during 1960, and construction under way will add less than 1,000 hp. of new capacity in 1961. This new capacity will be located on the Monquart River near Bath, and is expected to consist of two units operating under a maximum head of 80 feet.

Nova Scotia

1. Nova Scotia Power Commission

(a) Sissiboo Falls and Weymouth Falls, Sissiboo River: While originally scheduled for completion by mid-1960, delays in construction at both plants have resulted in postponement of their completion dates to 1961. The Sissiboo Falls plant will consist of one 8000-hp. unit. The Weymouth Falls plant will contain one 12,000-hp. unit.

(b) Under active consideration are developments at Riverdale on the Sissiboo River and at Wreck Cove on Wreck Cove Brook with proposed installations of 10,800 hp. and 90,000 hp. respectively.

2. Nova Scotia Light and Power Company Limited
(a) Lequille, Allain (Lequille) River: Construction was commenced in 1959 on a single-unit 7,500-hp. plant for service in 1961. The necessity for early completion of this plant has been rendered less urgent, however, by interconnection of power systems in Nova Scotia and New Brunswick. As a result, completion date for the plant has been postponed to 1963.
(b) Under active consideration is a single-unit 6,500-hp. development at Alpena on the Nictaux River with completion date scheduled for 1964.

Newfoundland

1. United Towns Electric Company Limited
Heart's Content, Heart's Content River: A single 3,200-hp. unit was installed to replace two smaller units which were dismantled. The total capacity of the dismantled units was 2,100 hp.

2. Iron Ore Company of Canada
Menihek Rapids, Ashuanipi River: The capacity of the plant was doubled by the addition of one 12,000-hp. unit.

3. Southern Newfoundland Power and Development Limited
Salmon River at the head of Bay d'Espoir: Proposed for construction is a development with a total capacity of up to 350,000 hp. Initial installation is expected to consist of two units of 38,500 hp. each.

4. Hamilton Falls Power Corporation Limited
Twin Falls, Unknown River: Construction proceeded for the installation in mid-1962 of two 60,000-hp. units as part of an ultimate development of 350,000 hp. This development is located on a tributary of the Hamilton River and is one of three subsidiary projects which may be built prior to construction of the main features included in the plan for Hamilton River development.

5. Bowater Power Company Limited
Hinds Brook: The Company proposes to install a 54,000-hp. development operating under a head of about 683 feet.

Yukon and Northwest Territories

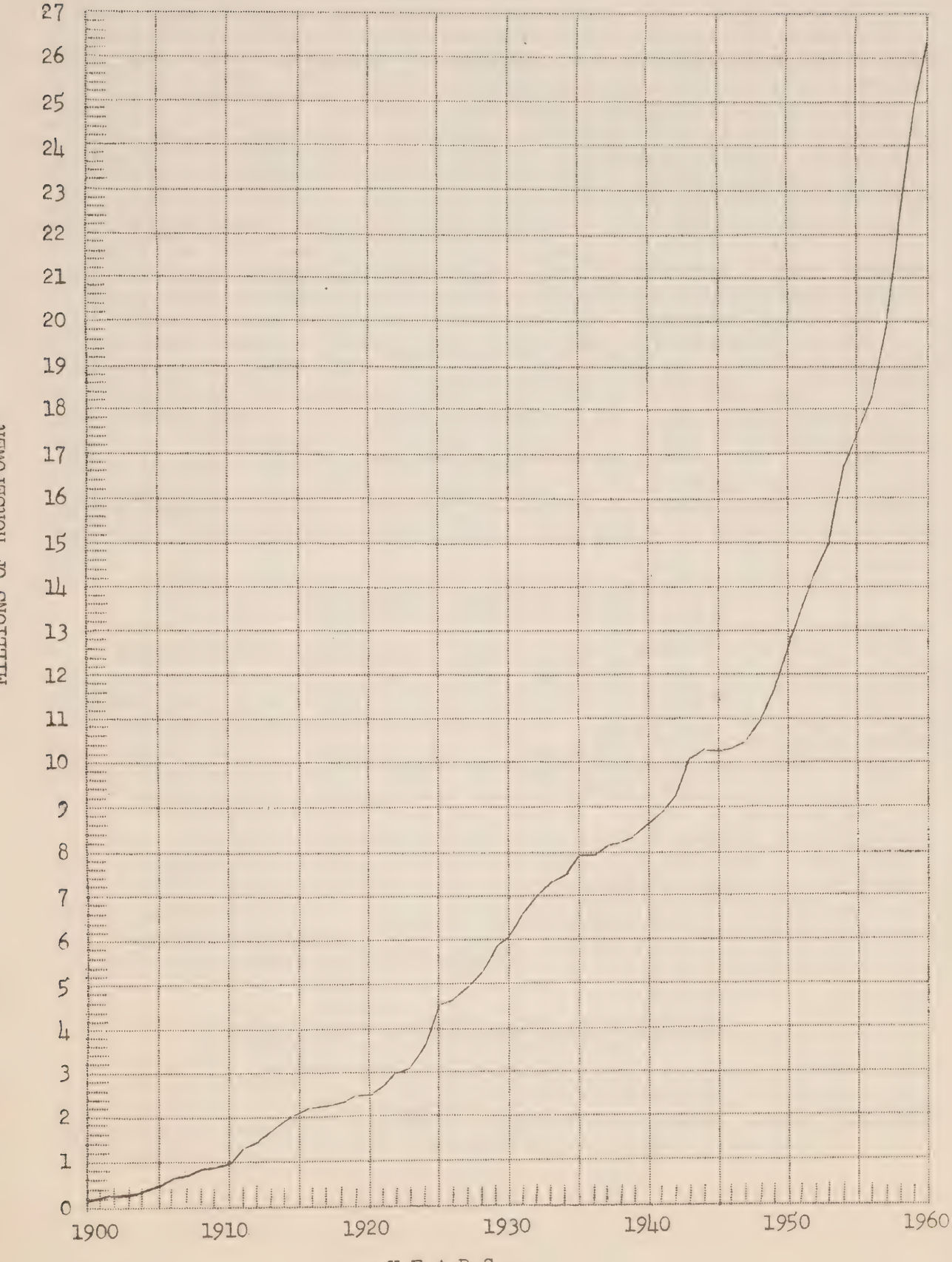
Northern Canada Power Commission
Snare Falls, Snare River, N.W.T.: A single 9,200-hp. unit was installed during the year, with provision made for a second unit of the same capacity when required.

GROWTH OF WATER POWER DEVELOPMENT

Since the inception of long-distance transmission of electricity near the beginning of the present century, water power development in Canada has undergone a remarkable growth, the total installation of 177,323 hp. at the end of the year 1900 being insignificant in comparison with the 26,375,444 hp. installed by the end of 1960. The rapid and continuous growth in installed capacity is illustrated in the diagram on the following page which shows the total installation in millions of horsepower at the end of each year for the period 1900 to 1960. The installed capacity of the Province of Newfoundland has been included in the total for Canada from 1949 onward.

TOTAL WATER POWER INSTALLATION IN CANADA

1900-1960



Since 1900, the rate of growth in the total capacity of water power installations in Canada has tended to accelerate. The average annual increase of 56,000 hp. in the period 1900-1905 was stepped up sharply in subsequent years, due largely to improvements in electric power transmission and to the building by utilities of large hydro-electric stations. During the period 1906-1922, development proceeded at the fairly uniform rate of 150,000 hp. per year. As a result of the heavier demand for electricity during the prosperous 1920's, the rate of installation increased appreciably in 1923 and continued at a nearly uniform rate of 377,000 hp. per year for the period 1923-1935. As large-scale hydro-electric projects require a long construction period, their completion tends to lag behind the demand for electric power which responds quickly to general economic conditions. The fall in power demand during the early 1930's is an illustration of this tendency -- projects under way were completed but the economic depression resulted in a low rate of installation during the years 1936-1939. The great demand for power for war purposes accounts for the high average rate of increase of 481,000 hp. per year during the period 1940-1943. Few developments were undertaken in the later war years or in the immediate post-war period, so that only a small amount of new capacity came into operation from 1944 to 1947 inclusive. However, the results of the later post-war programme of construction are apparent in the amount of growth during the thirteen-year period 1948 to 1960 inclusive when the average rate was over 1,200,000 hp. per year. Although estimates indicate only a moderate increase in installed capacity for 1961, present programmes of expansion point to the continuation of a rapid rate of growth for subsequent years.

COAL EQUIVALENT OF DEVELOPED WATER POWER

Apart from its production from water power, electric energy in large amounts is produced by thermal plants. The greater part of the total thermal-electric generation is derived at present from steam plants which burn coal; however, oil and natural gas are used also. The importance of water power in the economy of power production may be represented by the amount of coal which would have been consumed if steam had been used to produce the total amount of power realized from hydro-electric sources during 1960.

The total electric energy generated from water power in Canada during 1960 was about 105,774,000,000 kwh. Assuming that one pound of coal rated at 12,000 B.T.U. per pound is required to produce one kilowatt-hour of electricity by thermal-electric generation, the total 1960 water power output is equivalent to the burning of 52,887,000 tons of such coal, which would be in addition to the estimated 1960 consumption of 23,600,000 tons of coal of all types.

UTILIZATION OF INSTALLED WATER POWER CAPACITY

For the purpose of showing the general manner in which developed water power in Canada is utilized, Table II lists the hydraulic installation of each province and of the territories under two divisions, namely "Utilities" and "Industries". These are discussed on the following pages.

TABLE II

DISTRIBUTION OF INSTALLED WATER POWER CAPACITY

At End of Year 1960

Province or Territory	Turbine Installation - hp.		
	Utilities	Industries	Total
1	2	3	4
British Columbia	1,919,945	1,780,381	3,700,326
Alberta	413,390	1,065	414,455
Saskatchewan	125,500	6,635	132,135
Manitoba	973,000	15,900	988,900
Ontario	7,371,160	443,402	7,814,562
Quebec	8,842,978	3,597,167	12,440,145
New Brunswick	227,940	26,318	254,258
Nova Scotia	169,345	15,193	184,538
Prince Edward Is.	240	1,420	1,660
Newfoundland	270,305	113,720	384,025
Yukon and N.W.T.	40,740	19,700	60,440
Canada	20,354,543	6,020,901	26,375,444
Percentage	77	23	100

Utilities

The classification "Utilities", listed in Column 2 of the preceding table, covers companies, municipalities or individuals who sell most of the power they develop. In some instances it includes also certain subsidiary companies whose main purpose is to develop and sell power to a parent company for industrial purposes. The total of 20,354,543 hp. of installed capacity in hydro-electric plants operated by utilities represents 77 per cent of Canada's total installed capacity as at 31 December 1960.

Industries

The classification "Industries" in Column 3 of Table II includes those companies or individuals who develop power mainly for their own use. While the figures indicate that industries have developed only 23 per cent of Canada's total installed water power capacity, it must be emphasized that, in addition to the power generated in their own plants, industries purchase large amounts of power from utilities. For example, of the total of 32,291 million kilowatt-hours of electric energy made available in 1959 by the Hydro-Electric Power Commission of Ontario, about 28 per cent was sold direct to industrial customers. A discussion of the importance of water power in the pulp and paper industry and in the mineral industry, the largest users of this source of energy, follows:

The pulp and paper industry, which operated at below rated capacity during 1960, is one of the world's great industrial enterprises. In 1959, Canada's total mill capacity for the production of newsprint paper was over seven million tons per year which is much greater than that of any other country. (Canada is second only to the United States in the production of wood pulp). About 93 per cent of the manufactured newsprint is exported, making the industry a particularly important contributor to Canada's export trade balance.

The pulp and paper industry is a major industrial user of water power in Canada, its electric consumption representing about 19 per cent of the total electric energy produced in Canada. In 1959, the industry generated about 4,753 million kwh. for its own use and purchased an additional 14,618 million kwh. Most of the total of 19,371 million kwh. purchased or generated was produced by water power.

The relationship between the pulp and paper industry and water power development is an intimate one in that each contributes substantially to the other's expansion. As the manufacture of newsprint requires a mechanical installation of about 100 hp. for each ton of daily output, an ample supply of power at reasonable cost is essential to the industry.

In the mineral industry, although only a small number of water power plants are used directly to serve mining operations, smelting and refining operations require large amounts of hydro-electricity. In 1959 the mineral industry consumed about 21,349 million kwh. of electric energy, representing about 21 per cent of the total generated in Canada. Of the total consumed, more than 15,600 million kwh. was utilized in the smelting and refining of metals. Most of this amount was used for the production of aluminum. While Canada has no known deposits of bauxite, the availability of low-cost hydro-electric power has fostered the establishment of an aluminum industry which produces one-quarter of the world's supply of this metal.

The incidence of large water power resources in those regions of Canada in which the more important mineral discoveries have been made has greatly facilitated mining development. Metal mining, which forms an important part of the mining industry in Canada, is carried on mainly in two principal physiographic regions, the western Cordillera and the Canadian Shield. The topography of the mountainous regions and the relatively high amounts of precipitation experienced are two factors favourable to the development of water power, large quantities of which are used in mining and smelting operations. The Canadian Shield, a Precambrian formation in which many important metalliferous ores are found, forms a wide arc around Hudson Bay. The region has been heavily glaciated in recent geological times with the result that its river systems are comparatively young and are characterized by numerous lakes joined by short sections of rapids and falls. Many of these rivers and falls constitute suitable sites for the development of the hydro-electric power which is conducive to economic mining operations. The value of water power to mining operations is evident in the fact that Canada's asbestos industry, which in 1959 produced approximately half of the total world supply, depends almost exclusively upon hydro-electric power.

INSTALLED WATER POWER CAPACITY IN RELATION TO POPULATION

Tables III and IV show Canada's installed water power capacity in relation to population. Table III lists the estimated population of each province and of the territories on 31 December 1960 in comparison with the installed capacity of existing water power developments. Table IV lists the provinces and the territories in order of magnitude with respect to population, to total water power installation, and to per capita installation.

The figures listed for installation per thousand of population in the provinces and territories reflect in part the extent and character of the utilization of water power in each. The average for the whole country is 1,481 hp. per thousand of population, a factor which places Canada in an outstanding position with respect to water power development, second only to Norway among the countries of the world. On the basis of available information, Canada is exceeded only by the United States of America in total water power installation.

TABLE III

Province or Territory	Installed Capacity - hp. 31 Dec. 1960	Estimated Population 31 Dec. 1960	Installation per thousand of population hp.
British Columbia	3,700,326	1,606,000	2,304
Alberta	414,455	1,283,000	323
Saskatchewan	132,135	910,000	145
Manitoba	988,900	899,000	1,100
Ontario	7,814,562	6,089,000	1,283
Quebec	12,440,145	5,106,000	2,436
New Brunswick	254,258	600,000	424
Nova Scotia	184,538	723,000	255
Prince Edward Is.	1,660	103,000	16
Newfoundland	384,025	459,000	837
Yukon & N.W.T.	60,440	36,000	1,679
Canada	26,375,444	17,814,000	1,481

TABLE IV

Order of Magnitude	Provinces and Territories in order of magnitude with respect to: Population	Total Water Power Installation	Per Capita Installation
First	Ontario	Quebec	Quebec
Second	Quebec	Ontario	British Columbia
Third	British Columbia	British Columbia	Yukon and N.W.T.
Fourth	Alberta	Manitoba	Ontario
Fifth	Saskatchewan	Alberta	Manitoba
Sixth	Manitoba	Newfoundland	Newfoundland
Seventh	Nova Scotia	New Brunswick	New Brunswick
Eighth	New Brunswick	Nova Scotia	Alberta
Ninth	Newfoundland	Saskatchewan	Nova Scotia
Tenth	Prince Edward Is.	Yukon and N.W.T.	Saskatchewan
Eleventh	Yukon and N.W.T.	Prince Edward Is.	Prince Edward Is.

WATER POWER RESOURCES OF CANADA

BULLETIN No. 2721—62 MARCH 1963

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

WATER RESOURCES BRANCH

Woodcock Falls on the Fond du Lac River in northern Saskatchewan

WATER POWER RESOURCES

OF CANADA

BULLETIN No. 2721—62 MARCH 1963

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

WATER RESOURCES BRANCH

The following bulletins are issued annually by the Water Resources Branch:

"Development of Electric Power in Canada"
"Water Power Resources of Canada"
"Principal Power Developments in Canada"

Copies of these bulletins are available free of charge from the Director, Water Resources Branch, Department of Northern Affairs and National Resources, Ottawa 4, Canada.

Photographs were provided through the courtesy of the following organizations:

Saskatchewan Photographic Services
The Shawinigan Water and Power Company
The Hydro-Electric Power Commission of Ontario
British Columbia Department of Recreation and Conservation

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WATER POWER RESOURCES

OF CANADA

The Water Resources Branch of the Department of Northern Affairs and National Resources presents its annual review of Canada's water power resources and of their development to the end of 1962. Salient features such as the development of water power resources, distribution of resources in the provinces and territories, current progress in construction of generating stations, and industrial utilization of power are discussed briefly.

One of the most important factors in Canada's economic development has been the availability of large quantities of low-cost electric power. Less than 50 years ago, the Canadian economy was based essentially upon the export of agricultural products and raw materials, most of the latter going to feed the manufacturing industries of other countries; today, the part played by industry in the nation's economy is one of vital importance. The transition to a more highly industrialized economy has been accompanied by a steady expansion in electric generating facilities,

principally of hydro-electric origin. The close relationship between electric power development and industrial expansion is particularly evident in southern Québec and Ontario. Although they lack indigenous coal, these regions are the most highly industrialized in the country, largely through the development and use of their abundant water power resources.

At present, most of Canada's electric power demands are satisfied from hydro-electric sources. By the end of 1962, the country's total installed hydraulic capacity had grown to 27,103,562 hp.* Of this total, 415,468 hp. of new capacity was placed in service during 1962. Within the next few years, a number of developments, at present under construction, will add very substantially to the nation's total hydro capacity.

The last few years have seen a marked trend towards the use of thermal facilities for generating electric power. This is due in part to the fact that most of the hydro-electric sites considered within economic transmission distance of demand centres had been developed and planners had looked elsewhere for sources of electric power to satisfy growing requirements. It is due also to increasing recognition of the benefits of integrating the operation of hydro and thermal plants. Advances in the techniques of extra-high-voltage transmission are providing, however, a renewed impetus to the development of a number of water power sites previously considered too remote. The promise of greater effectiveness in the use of water power resources inherent in the development of long-distance transmission facilities, led the Government of Canada to convene a federal-provincial conference in 1962 to discuss the problems involved, not only in the transmission of electrical energy over long distances, but also in the possible formation of a national power grid.

TOTAL AVAILABLE AND DEVELOPED WATER POWER

Table I lists by province or territory the estimated total water power resources of Canada and the total existing capacity of all water power plants, determined from the records of the Water Resources Branch. Under agreement with provincial authorities, the Branch carries out hydrometric investigations on rivers throughout the country and maintains continuous streamflow records accumulated from many sources. Estimates of available power are revised as long-term streamflow records and detailed information on potential power sites are obtained. Close liaison is maintained with the Dominion Bureau of Statistics in the collection of information on developed water power and power output.

* The total thermal-electric capacity at the end of 1962 was slightly more than 5.7 million kilowatts.

TABLE I

AVAILABLE AND DEVELOPED WATER POWER IN CANADA

at 31 December 1962

Province or Territory	Available Continuous Power at 80% Efficiency		Installed Turbine Capacity hp.
	At Ordinary Min. Flow hp.	At Ordinary 6-Month Flow hp.	
(1)	(2)	(3)	(4)
British Columbia	18,200,000*	19,400,000*	3,701,326
Alberta	911,000	2,453,000	414,455
Saskatchewan	552,000	1,131,000	142,135
Manitoba	4,758,000**	8,454,000**	988,900
Ontario	5,496,000	7,701,000	7,959,512
Québec	12,557,000***	23,711,000***	12,816,845
New Brunswick	123,000	334,000	309,726
Nova Scotia	30,500	177,000	204,538
Prince Edward Island	500	3,000	1,660
Newfoundland	1,608,000	3,264,000	504,025
Yukon Territory	4,678,000*	4,700,000*	38,190
Northwest Territories	1,367,000*	1,791,000*	22,250
CANADA	50,281,000*	73,123,000*	27,103,562

* These figures reflect the effect of possible streamflow regulation based on known storage potentials.

** These figures show a significant increase as a result of a recent major review of the records maintained by the Water Resources Branch and the Manitoba Water Control and Conservation Branch.

*** These figures undoubtedly will be revised substantially upon completion of a review of water power resources now being carried out by the Québec Department of Natural Resources with the co-operation of the Water Resources Branch.

Available Water Power

Column 2 of Table I lists the estimated continuous power ordinarily available during periods of low discharge under existing conditions of river flow. These estimates are based upon the "Ordinary Minimum Flow", which is the average of the mean flows for the two lowest periods of seven consecutive days in each year covered by the period of record.

Column 3 lists the estimated dependable maximum power based on the "Ordinary Six-Month Flow", which is the dependable streamflow usually available for a least six months in the year under existing flow conditions.

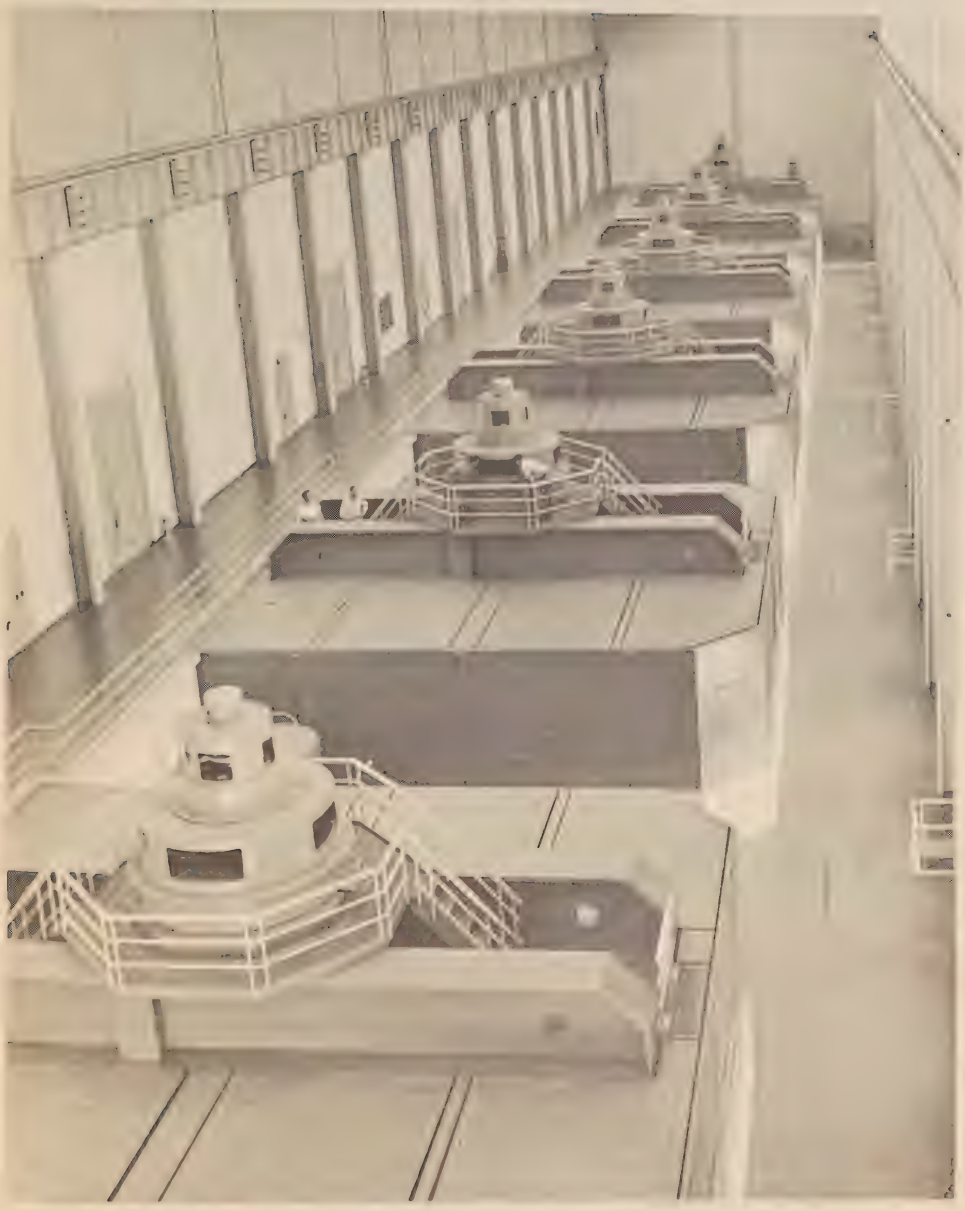
On rivers for which there are no discharge records, estimates of flow are made from available information relating to runoff in the same general area.

The hydraulic head used in calculating available power is based upon the actual drop, or feasible concentration of head, which has been measured, or at least carefully estimated, at existing falls, rapids and known power sites. No consideration has been given to possible economic concentrations of head on rivers and streams of gradual gradient, except at those locations where the available head has been definitely established by field investigations.

It should be emphasized that the figures of available power in Columns 2 and 3 represent only the minimum water power possibilities of Canada. Many unrecorded power sites exist on rivers and streams throughout the country, particularly in the less explored northerly districts. As power surveys are extended, detailed information on new sites will become available, and undoubtedly, substantial additions to present figures of available power will result. With the exception of British Columbia and the Yukon Territory, estimates of available power are based upon existing river flows and do not take into account the benefits of streamflow regulation that would result from the development of storage potential. In addition, it should be pointed out that the figures of available power do not include the power potential of major river diversions that have been investigated but not developed. For example, the potential of the Chilko River itself has been included in the total for British Columbia, but the potential of the Chilko-Homathko River diversion, quoted in some publications as 1,000,000 hp., is not included. Several other major diversion possibilities exist, particularly in British Columbia, where topographical conditions make rearrangements of flow possible.

Developed Water Power

The figures of installed turbine capacity, listed in Column 4 of



Interior of the powerhouse at Trenche hydro-electric development
on the St. Maurice River, Québec

Table I, are the totals of plant capacities based upon the manufacturer's rating as indicated on the name-plate of each unit. In exceptional circumstances where, subsequent to the initial development, a change in the normal operating head has been effected, a rating based on the new normal operating head is used.

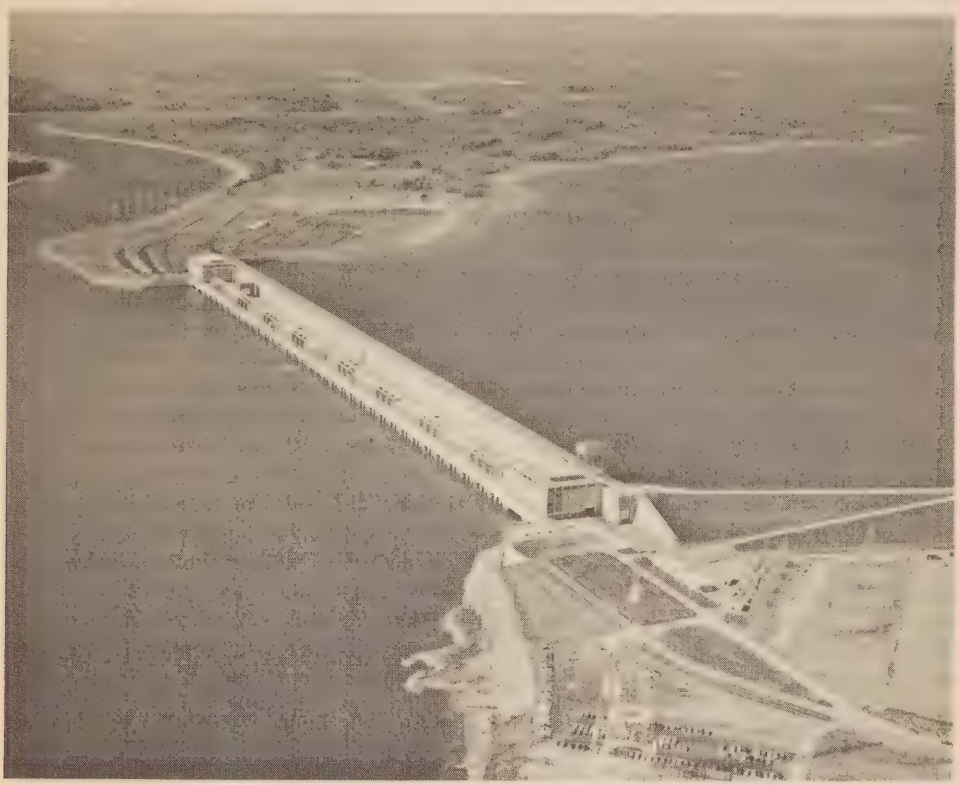
The maximum economic turbine installation at any power site can be determined only by careful consideration of all the conditions and circumstances pertinent to its individual development. It is the usual practice, however, to install turbines which have a total capacity in excess of the power equivalent of the ordinary six-month flow at the site. This additional capacity may be installed for use at peak-load hours or to facilitate plant or system maintenance, or to take advantage of periods of high river flow. In some instances, subsequent to initial development, storage dams have been built to provide more uniform river flows. In others, deficiencies in power output during periods of low flow have been offset by auxiliary power from thermal-electric plants or by interconnection with other hydro-electric plants, which operate under different load conditions or are located on rivers having different flow characteristics.

The extent to which the installed capacity exceeds the power equivalent of the ordinary six-month flow is dependent upon the factors which govern the system of power-plant operation, and varies widely in different areas of the country. In some individual developments, the difference may amount to as much as several hundred per cent. For this reason, the figures in Column 4 are not directly comparable with those in Column 3. For the same reason, it is not feasible to forecast future capacity installation based upon estimates of available water power.

DISTRIBUTION OF WATER POWER IN THE PROVINCES AND TERRITORIES

Although extensive use is being made of Canada's water power resources at the present time, many large power sites in various parts of the country have yet to be developed. In northern regions, it is probable that the existence of large amounts of potential water power will prove to be a factor of prime importance in the eventual realization of the natural wealth of Canada's North.

Table I indicates the manner in which available water power and installed turbine capacity in Canada are distributed throughout the provinces and territories. A review of the table shows that substantial amounts of water power have been developed in all the provinces except Prince Edward Island, where water power resources are relatively insignificant. As the development of Canada's natural resources proceeds, the fortunate incidence of water power in proximity to mineral deposits, pulpwood and other natural resources becomes increasingly apparent.



Robert H. Saunders - St. Lawrence Generating Station and Robert Moses Power Dam spanning the St. Lawrence River between Canada and the United States. In the background can be seen the Long Sault Dam.

BRITISH COLUMBIA, traversed by three distinct mountain ranges and with, generally speaking, a high rate of precipitation, has many mountain rivers offering abundant opportunity for the development of hydro-electric power. In terms of recorded available water power resources, the province ranks second in Canada, and is exceeded only by Québec and Ontario in the amount of capacity installed.

Notable for the magnitude of their power potential are such rivers as the Columbia, Fraser, Peace and Stikine. Up to the present time, however, hydro-electric developments on smaller rivers in the southern part of the province have been called upon to supply the major load requirements of British Columbia. The immense power resources of the larger rivers have gone unused, largely due to considerations associated with international agreement on development, conflicts of interest between fisheries and power development, or because of comparative remoteness from present demand areas.

In March 1962, as a result of legislation enacted by the Government of British Columbia, the former British Columbia Power Commission and the British Columbia Electric Company Limited were

amalgamated to form the provincially-owned power producing and distributing agency known as British Columbia Hydro and Power Authority. The Authority, with a total installed hydro-electric capacity of 1.7 million hp., is the province's foremost producer of electric power.

In ALBERTA, the principal hydro-electric developments are located on the Bow River and its tributaries, and from these developments, Calgary Power Ltd. serves most of the southern part of the province. Substantial water power resources are located in northern regions of the province, but these are somewhat remote from present centres of population. Alberta's abundant reserves of coal, oil and natural gas are used to fuel the thermal-electric plants which supply a large part of the province's electric power requirements.

In SASKATCHEWAN, large water power resources exist in the central and northern parts of the province, principally on the Churchill, Fond du Lac, and Saskatchewan Rivers. At present, hydro-electric power generated in the province is used almost exclusively for mining purposes in northern areas. However, by the end of 1963, first power from developments at present under construction in the Saskatchewan River basin will be fed into the transmission network of the provincially-owned Saskatchewan Power Corporation, which serves the more settled areas of the province. These areas are now served by thermal-electric plants fuelled by coal, oil, or natural gas, all of which are found in considerable quantity in the province.

Of the three Prairie Provinces, MANITOBA, with immense hydro-electric capabilities on the Winnipeg, Churchill, Nelson and Saskatchewan Rivers, is the most generously endowed with water power resources. Until recently, hydro-electric generating stations on the Winnipeg River have supplied most of the electric power requirements in southern Manitoba. With the advent of high-voltage, long-distance transmission, however, power from hydro-electric stations on northern rivers will be carried south to help meet the province's constantly growing power demands.

ONTARIO has been favoured with abundant water power resources. It has, however, developed the greater part of its recorded available power with the result that it surpasses all of the provinces except Québec in terms of installed hydro-electric capacity. The Hydro-Electric Power Commission of Ontario, the largest power-producing and distributing organization in Canada, operates sixty-seven hydro-electric generating stations with a combined installed capacity of approximately 7,000,000 hp. The Commission's largest water power development is located on the Niagara River at Queenston, where the Sir Adam Beck - Niagara Generating Stations Nos. 1 and 2, and the associated pumping-generating station have a combined capacity of 2,521,000 hp. In addition to the power generated in its own plants, the Commission purchases large amounts of electric power generated outside the province, chiefly in Québec.

QUÉBEC is richest of all the provinces in water power resources, possessing more than 30 per cent of the total recorded for Canada. Québec also leads in developed water power - its present installation of 12,816,845 hp. representing about 47 per cent of the national total. The largest single hydro-electric installation in Canada is the Québec Hydro-Electric Commission's 2,161,000-hp. Beauharnois development on the St. Lawrence River. Also notable are the Commission's Bersimis I development on the Bersimis River with an installed capacity of 1,200,000 hp., and the Aluminum Company of Canada Limited's 1,200,000-hp. Shipshaw plant on the Saguenay River. A major power scheme which will represent a significant advance in the development of Québec's hydro-electric resources is now in course of construction by the Québec Hydro-Electric Commission. This scheme, involving the harnessing of the headwaters of the Manicouagan and Outardes Rivers, will eventually make available nearly 6,000,000 hp. of new capacity at new and existing developments on the two rivers.

Power production in the province is facilitated by the regulation of streamflow by the Québec Department of Natural Resources through the storage dams which it owns and operates.

The mandate given to the government of the province by the people of Québec at the elections in November 1962 may result in action to bring eleven privately-owned utilities under public ownership.

The water power resources of NEW BRUNSWICK and NOVA SCOTIA, although small in comparison with those of other provinces, are a valuable source of energy and are being well utilized. Numerous rivers in both provinces provide moderate-sized power sites either within economic transmission distance of the principal cities and towns or advantageously situated for use in development of the timber and mineral resources. These provinces also are favoured with abundant indigenous coal supplies. In PRINCE EDWARD ISLAND, there are no large streams and consequently water power plants are limited in size to those used for small mills.

The water power resources of NEWFOUNDLAND, determined on the basis of limited streamflow data, are estimated to be of considerable magnitude. On the island, although the length of the rivers is generally not great, topography and runoff are favourable for hydro-electric power development. Of the substantial capacity installed, a very large portion serves the pulp and paper industry. In Labrador, the Hamilton River and its tributaries constitute one of the largest undeveloped sources of water power in Canada.

The YUKON TERRITORY and NORTHWEST TERRITORIES, which together comprise Canada's northland, possess extensive water power resources. Power from present developments is used exclusively to satisfy the needs of local mines and adjacent settlements. Due to the lack of developed native fuel sources and to transportation difficulties, water power is of special importance in the development of mining areas such

as at Yellowknife in the Northwest Territories and at Mayo in the Yukon Territory. In 1948, to encourage the development of the resources of northern Canada, the Federal Government established an agency, now known as the Northern Canada Power Commission, to be responsible for the construction and management of public utility plants. The Deputy Minister of Northern Affairs and National Resources is Chairman of the Commission and the Director of the Water Resources Branch is a Member.

In the YUKON TERRITORY, most of the resources are located on the Yukon River and its tributaries. The possibility exists of diverting the headwaters of the Yukon River through the Coast Mountains to utilize a high head near tide water in northern British Columbia. Such a development, however, would affect adversely the potential of sites on the main river.

Resources in the NORTHWEST TERRITORIES have not been surveyed to the same extent as those in the Yukon Territory, but they are nevertheless known to be of considerable magnitude. Extensive water power resources exist on rivers flowing into Great Slave Lake. Of major significance is the hydro-electric potential existing on the South Nahanni River, which drains to the Mackenzie River via the Liard River. On the basis of preliminary investigations, it is estimated that, with total regulation and complete use of the head susceptible of development, the hydro-electric potential of the South Nahanni River would total at least one million continuous horsepower. Indications are that the rivers draining the Keewatin District, lying north of Manitoba, also will contribute materially to the total power potential of the Northwest Territories.

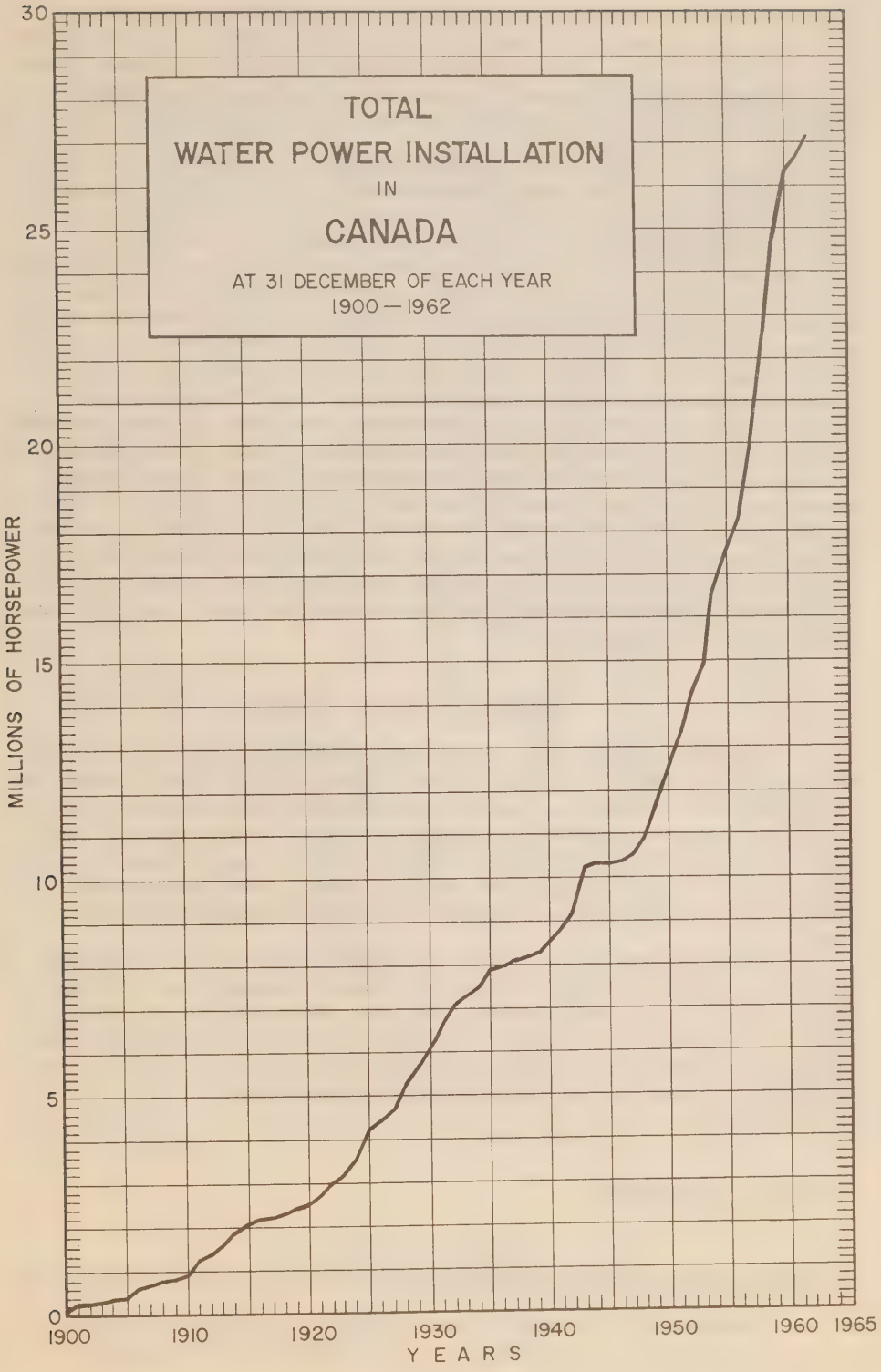
DEVELOPMENT OF WATER POWER RESOURCES

Water power development in Canada has undergone remarkable and sustained growth since the beginning of the century. The diagram on page 15 illustrates this growth in terms of the expansion in installed turbine capacity over the years from 1900 to 1962.

Historical Summary

From a modest total of 177,323 hp. installed at the end of 1900, Canada's total turbine capacity has grown to the significant total of 27,103,562 hp. at the end of 1962.

Over the years, the rate of growth in the total water power capacity in Canada has tended to accelerate. The average annual increase from 1900 to 1905 was 56,000 hp. From 1906 to 1922, the rate increased


TOTAL
WATER POWER INSTALLATION
IN
CANADA
AT 31 DECEMBER OF EACH YEAR
1900 — 1962
MILLIONS OF HORSEPOWER
0
5
10
15
20
25
30
1900
1910
1920
1930
1940
1950
1960
1965
YEARS

sharply to about 150,000 hp. annually, due largely to improvements in electric power transmission and to the increasing emphasis on large hydro-electric stations. As a result of the heavier demand for electricity during the prosperous 1920's, the rate of installation increased appreciably in 1923 and continued at a fairly uniform rate of 377,000 hp. per year until 1935.

As large-scale hydro-electric projects require a long construction period, their completion tends to lag behind the electric power demand which responds quickly to general economic conditions. The fall in power demand during the early 1930's is an illustration of this tendency - projects under way were completed but the economic depression resulted in a low rate of installation during the period 1936-1939. The great demand for power for war purposes accounts for the high average rate of increase of 481,000 hp. per year during the period 1940-1943. Few new developments were initiated in the latter years of the war or in the immediate post-war period, so that, from 1944 to 1497, only a small amount of new capacity came into operation. Soon after the war, however, the programme of construction of hydro-electric plants gained momentum, and the results are apparent in an average annual rate of installation exceeding 1,200,000 hp. during the period 1948 to 1960. In sharp contrast are the comparatively moderate net totals of 294,650 hp. and 415,468 hp. of new capacity put into service in 1961 and 1962 respectively. A resumption of the previous high rate of installation can be expected in 1963 however, when a number of hydro-electric projects at present under construction are completed.

Progress During 1962

The 1962 increase of 415,468 hp. in Canada's total hydro-electric turbine capacity was almost 50% greater than the 294,650 hp. brought into service in 1961. Moreover, on the basis of present information, 1963 should see a greater number of completions in the hydro-electric field, with an anticipated 1.2 million horsepower of new capacity being brought into operation. Estimates for the years following 1963 indicate an expansion in hydro-electric facilities of almost 8 million horsepower.

A detailed review of new and prospective water power developments is presented in Water Resources Branch Bulletin No. 2720-62, "Development of Electric Power in Canada - Progress Report 1962", issued in January 1963. However, the following summary lists the hydro-electric developments completed or under construction during 1962, or proposed for construction within the next few years.

British Columbia

CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA LTD.

Waneta, Pend d'Oreille River: Installation of a third 120,000-hp. unit continued on schedule and is expected to be completed

Waneta hydro-electric plant on the Pend d'Oreille River,
British Columbia

in April 1963. Present total capacity of the plant is 240,000 hp. in two units.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

1. Portage Mountain, Peace River: Two contracts for preliminary work connected with development of the Peace River were completed in 1962. Contract for the main dam at Portage Mountain site is expected to be awarded in 1963 and first power is scheduled for 1968.

2. Columbia River: Investigation of Duncan Lake, High Arrow and Mica storage projects was continued. These three projects, development of which constitutes the basis of the Columbia River Treaty signed by Canada and the United States in 1961, would be capable of controlling approximately twenty million acre-feet of usable storage in Canada. The Treaty provides that Canada will receive half of the power benefits resulting in the United States from the regulation of 15.5 million acre-feet of this storage, and half the value of the estimated flood damage prevented in the United States through operation of the projects for flood control. The Treaty has not yet been ratified by Canada.

Alberta

CALGARY POWER LTD.

Big Bend, Brazeau River: The storage dam was completed and construction of the powerhouse continued at this site, about 15 miles upstream from the confluence of the Brazeau and North Saskatchewan Rivers. A single 200,000-hp. unit is expected to be in service late in 1964. The installation of additional units would necessitate increasing the height of the storage dam above the level to which it is now being built.

Saskatchewan

SASKATCHEWAN POWER CORPORATION

1. Coteau Creek site, South Saskatchewan River: Construction continued on the South Saskatchewan River Project which is being developed by the Prairie Farm Rehabilitation Administration primarily for irrigation purposes. Associated power facilities will be incorporated at the main dam by the Saskatchewan Power

Corporation, which plans an initial installation of three units of about 60,000 hp. each, and provision for two additional units to give the project an ultimate capacity of 300,000 hp.

2. Squaw Rapids, Saskatchewan River: Construction continued at this development which, when completed, will comprise 375,200 hp. in eight units. The first four units will be commissioned at intervals from February to September 1963, two others in 1964 and the remaining two in 1966.

Manitoba

MANITOBA HYDRO

Grand Rapids, Saskatchewan River: Construction of this development went ahead on schedule. Initial installation will consist of three 150,000-hp. units, two of which are scheduled to go into service in late 1964 and the third in early 1965. Provision is being made for a fourth unit.

Ontario

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

1. Otter Rapids, Abitibi River: Operation of this plant commenced in 1961 with the installation of two 60,000-hp. units. Two more units of the same capacity are scheduled for service in 1963. Provision for four additional units has been made to the extent that the headworks structure and headgates for the units have been installed.

2. Mattagami River: Active progress was reported on construction at two of three developments which will be located on a 12-mile reach of the river in the general location of the existing Smoky Falls hydro-electric station. Initially, a combined total of 544,000 hp. is scheduled to be installed at the three developments. Provision is being made for the eventual installation of an additional 544,000 hp.

Little Long: The current construction programme calls for the installation of two 84,000-hp. units in 1963, with provision for a further two units at a later date.

Harmon: Initial construction started at this site where the Commission plans to install two 94,000-hp. units by 1965. Provision will be made for two additional units.

Kipling: Topographic surveys and diamond drilling were carried out in 1962 to determine the most suitable arrangement for the proposed earth dams. By 1966 the plant is expected to have two 94,000-hp. units in operation, with provision for two additional units.

GREAT LAKES POWER COMPANY LIMITED

1. Site 2A, Montreal River: Consideration is being given to the construction of a single-unit 20,000-hp. plant at this site. The schedule indicates initial operation in 1964.

2. Lower Falls, Montreal River: The Company is considering the addition of a third unit at this plant. The proposed 28,000-hp. unit, to go into service in 1966, would increase the total generating capacity of the plant to 50,000 hp.

Québec

QUÉBEC HYDRO-ELECTRIC COMMISSION

1. Carillon, Ottawa River: The first four units of 60,000 hp. each, saw initial service in 1962. Eight other units are scheduled for installation in 1963, and the project should be complete in 1964 with a total installed turbine capacity of 840,000 hp. in fourteen units.

2. Rapid II, Ottawa River: The Commission continued studies on a proposal to increase the installed capacity of this plant. The proposal involves the addition of a 16,000-hp. unit to bring the plant to its ultimate capacity of 64,000 hp. in four units. No decision has been announced as yet concerning the date of installation of this proposed unit.

3. Manicouagan and Outardes Rivers: Considerable progress was reported on construction of a multi-development project, designed to realize some 3,650,000 hp. at three sites on the Manicouagan River and a further 1,440,000 hp. at two sites on the Outardes River. In addition, regulation from upstream reservoirs will permit capacities at existing plants on the two rivers to be increased by 627,000 hp.

Manicouagan 5: Construction of the huge dam at the Manicouagan 5 site was started in 1962. At this site, just below the outlet of Manicouagan Lake, the Commission proposes to install eight units with a total turbine capacity of approximately 1.5 million horsepower.

Manicouagan 2: Preliminary construction was well advanced at the Manicouagan 2 site, located about 10 miles from the mouth of the Manicouagan River. Proposed development of the site involves the installation of ten 110,000-hp. units. Power is expected to be available from Manicouagan 2 before the end of 1965.

Manicouagan 3: Plans for the development of the Manicouagan 3 site, 50 miles from the river's mouth, call for the installation of seven 150,000-hp. units.

Outardes 58 and Outardes 45: Power studies of the Outardes River have established the feasibility of installing capacities of 700,000 hp. and 740,000 hp. respectively at the Outardes 58 and Outardes 45 sites, so designated because of their distances from the confluence of the Outardes and St. Lawrence Rivers.

SHAWINIGAN WATER AND POWER COMPANY

Rapide des Coeurs, St. Maurice River: The Company has postponed indefinitely plans for construction of this plant, designed to house four 42,000-hp. units, with provision for a fifth unit. Initial operation had originally been scheduled for 1965.

New Brunswick

NEW BRUNSWICK ELECTRIC POWER COMMISSION

1. Beechwood, Saint John River: The 55,000-hp. unit installed in April brings the plant to its full designed capacity of 145,000 hp. in three units.

2. Milltown, St. Croix River: A 468-hp. unit went into service in May, raising the plant capacity to 4,208 hp. in five units.

3. Mactaquac, Saint John River: Preliminary engineering studies were continued for the development of up to 600,000 hp. at this site on the Saint John River, fifteen miles upstream from Fredericton.

Nova Scotia

NOVA SCOTIA POWER COMMISSION

Consideration is being given to the construction of two developments, one at Riverdale on the Sissiboo River and the other at Wreck Cove on Wreck Cove Brook. Plans for Riverdale call for installation of a single 8,000-hp. unit, while estimates for the Wreck Cove plant indicate a possible ultimate capacity of 90,000 hp. There is as yet no indication of when construction of either development will commence.

NOVA SCOTIA LIGHT AND POWER COMPANY LIMITED

1. Lequille, Allain (Lequille) River: Preliminary construction was carried out at this site in 1959. The need for power from this 7,500-hp. development was rendered less urgent, however, by interconnection of power systems in Nova Scotia and New Brunswick, and completion of the project is not likely to take place before 1970.

2. Nictaux, Alpena River: The Company is considering the installation of a single 6,500-hp. unit at this site, but this unit is not expected to be installed before 1968.

Newfoundland

TWIN FALLS POWER CORPORATION LIMITED

Twin Falls, Unknown River: Two 60,000-hp. units were brought into service in June 1962 and two more identical units are scheduled to be added in late 1963. Ultimate development of the site is expected to be 300,000 hp. in five units.

NEWFOUNDLAND LIGHT AND POWER COMPANY LIMITED

Sandy Brook: Development of a site about eight miles west of the town of Grand Falls was begun in 1962. Initial installation at the site will be a single 8,000-hp. unit, scheduled to commence operating in late 1963.

SOUTHERN NEWFOUNDLAND POWER AND DEVELOPMENT LIMITED

Head Bay d'Espoir, Salmon River: The Company is planning to construct a development which is expected to consist initially of 77,000 hp. in two units and ultimately of up to 350,000 hp. However, a date for the start of construction has not yet been scheduled.

BOWATER POWER COMPANY LIMITED

Hinds Brook: The Company proposes to install a 54,000-hp. development. Construction of the project has not yet been scheduled.

Northwest Territories

NORTHERN CANADA POWER COMMISSION

Taltson River: Investigation of a site about 35 miles northeast of Fort Smith was carried out during the summer of 1962. On the basis of this investigation, the Commission considers that an initial installation of 25,000 hp. is feasible at this site.

COAL EQUIVALENT OF DEVELOPED WATER POWER

At present, large amounts of electric energy are generated by thermal plants, most of which are fuelled by coal. For the purpose of illustrating the importance of hydro-electric energy to the nation's power economy, it may be helpful to express the total hydro-electric energy generated in Canada in 1962 in terms of the amount of coal that would have been necessary to produce the same amount of energy in steam plants.

The total amount of electric energy generated from water power in Canada during 1962 was approximately 110,000 million kilowatt-hours. Assuming that one pound of coal rated at 12,000 B.T.U. per pound is required to produce one kilowatt-hour of electricity by thermal-electric generation, the total 1962 water power output would be equivalent to the burning of 55 million tons of coal. This theoretical quantity would be in addition to the estimated total of 23,800,000 tons of coal of all types actually consumed in 1962.

UTILIZATION OF INSTALLED WATER POWER CAPACITY

For the purpose of illustrating the general manner in which developed water power in Canada is used, Table II lists the water power capacity installed in the provinces and territories under the two divisions "Utilities" and "Industries".

TABLE II

DISTRIBUTION OF INSTALLED WATER POWER CAPACITY

at 31 December 1962

Province or Territory	Turbine Installation - hp.		
	Utilities	Industries	Total
(1)	(2)	(3)	(4)
British Columbia	1,920,945	1,780,381	3,701,326
Alberta	413,390	1,065	414,455
Saskatchewan	125,500	16,635	142,135
Manitoba	973,000	15,900	988,900
Ontario	7,516,110	443,402	7,959,512
Québec	9,159,678	3,657,167	12,816,845
New Brunswick	283,408	26,318	309,726
Nova Scotia	189,345	15,193	204,538
Prince Edward Island	240	1,420	1,660
Newfoundland	390,305	113,720	504,025
Yukon and N.W.T.	40,740	19,700	60,440
CANADA	21,012,661	6,090,901	27,103,562
Percentage of Total Installation	78	22	100

Utilities

The classification "Utilities" in Column 2 of Table II, refers to companies, municipalities or individuals who sell most of the power they develop. In some instances it also includes certain subsidiary companies whose main purpose is to develop and sell power to a parent company for industrial purposes. The total of 21,012,661 hp. of installed capacity in hydro-electric plants operated by utilities represents 78 per cent of Canada's total installed capacity at 31 December 1962.

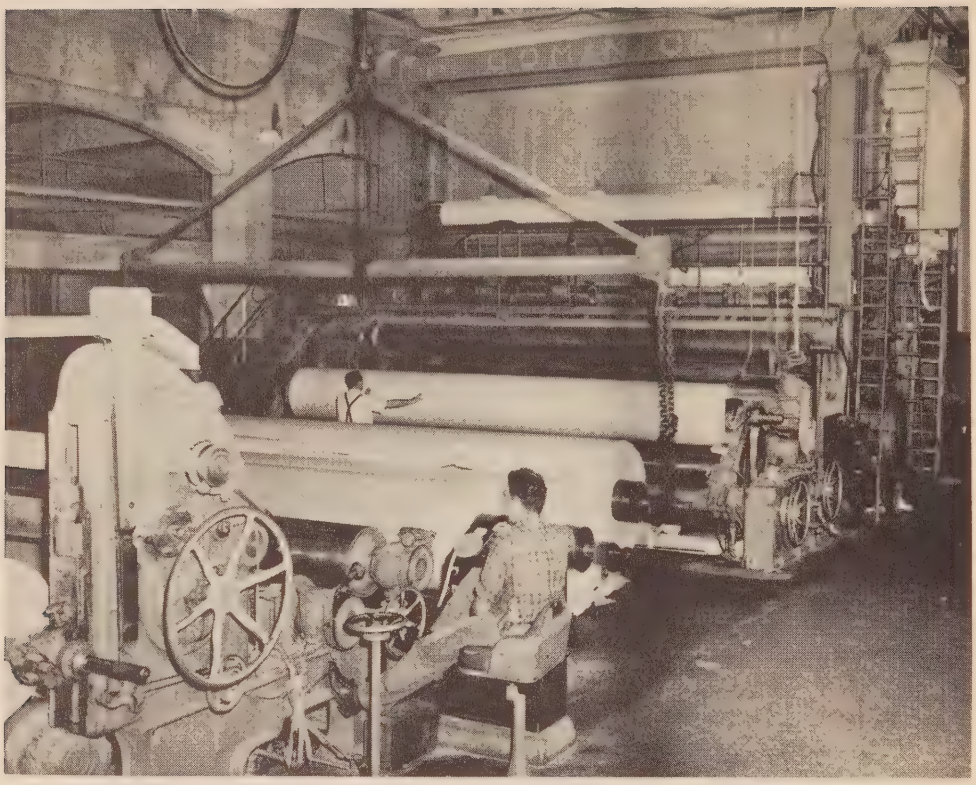
Industries

The classification "Industries" in Column 3 of Table II refers to those companies or individuals who develop power mainly for their own use. While the figures indicate that industries have developed only 22 per cent of Canada's total installed water power capacity, it should be emphasized that, in addition to the power generated in their own plants, industries purchase large amounts of power from utilities. For example, of the total of 34,994 million kilowatt-hours of electric energy made available in 1961 by the Hydro-Electric Power Commission of Ontario, almost half was purchased by industrial customers, either directly from the Commission or through municipal electric utilities or local systems.

The pulp and paper industry in Canada is one of the world's great industrial enterprises and is one of the foremost users of hydro-electric energy in Canada. Total mill capacity for the production of newsprint paper is considerably greater than that of any other country in the world, and in terms of wood pulp production, Canada is second only to the United States. The fact that over 90 per cent of the manufactured newsprint is exported gives some indication of the importance of the industry to Canada's export trade programme.

The relationship between pulp and paper production and water power supply is an intimate one in that each contributes substantially to the other's expansion. The industry consumes nearly one-fifth of the total electric energy generated in Canada. By far the largest portion of the energy used is derived from water power.

In the mineral industry, although only a few water power plants are used directly to serve mining operations, there are nevertheless large amounts of electric energy consumed, principally in the smelting and refining processes. More than one-fifth of the electric energy generated in Canada is consumed in the mineral industry, with about 75 per cent of this amount used in the smelting and refining of metals.



High-speed newsprint machine at Powell River, British Columbia

Although Canada has no known deposits of bauxite, the availability of low-cost hydro-electric power has fostered the establishment of an aluminum industry which produces one-quarter of the world's supply of this metal. Further evidence of the value of water power to mining operations is provided by the fact that Canada's asbestos industry, which produces approximately half of the total world supply of asbestos, obtains the major part of its power supply from hydro-electric sources.

The incidence of large water power resources in those regions in which the more important mineral deposits have been found, has greatly facilitated mining development. Metal mining, a very important division of the Canadian mining industry, is carried on mainly in two physiographic regions, the Western Cordilleras and the Canadian Shield.

The mountainous topography of the Western Cordilleras and the relatively high amounts of precipitation favour the development of water power. Many important metalliferous ores are found in the Canadian Shield, a Precambrian formation stretching from the Mackenzie River basin to the eastern tip of Labrador in a wide sweep around Hudson Bay. Due to the heavy glaciation of the region in recent geological times, the

river systems are comparatively young and are characterized by large numbers of lakes connected by short river sections with numerous rapids and falls suitable for development as hydro-electric power sites.

INSTALLED WATER POWER CAPACITY IN RELATION TO POPULATION

Based upon the latest statistics of population available, Tables III and IV indicate the relationship between installed water power capacity

TABLE III

Province or Territory	Installed Capacity - hp. 1962	Estimated Population 1962	Installation per thousand of population hp. - 1962
British Columbia	3,701,326	1,659,000	2,231
Alberta	414,455	1,370,000	303
Saskatchewan	142,135	930,000	153
Manitoba	988,900	935,000	1,058
Ontario	7,959,512	6,342,000	1,255
Québec	12,816,845	5,366,000	2,389
New Brunswick	309,726	607,000	510
Nova Scotia	204,538	746,000	274
Prince Edward Island	1,660	106,000	16
Newfoundland	504,025	470,000	1,072
Yukon & N.W.T.	60,440	39,000	1,550
CANADA	27,103,562	18,570,000	1,460

and population in Canada. Table III lists the estimated population of the provinces and territories in comparison with the installed capacity of water power developments. Table IV lists the provinces and territories in order of magnitude with respect to population, total water power installation, and per capita installation.

The figures listed in the column headed "installation per thousand of population" in Table III reflect in part the extent and character of the use of water power in the provinces and territories. In terms of installed water power capacity per thousand of population, Canada, with a national average of 1,460 hp., is second only to Norway, and in terms of total installed hydraulic turbine capacity, is surpassed only by the United States of America.

TABLE IV

Order	Provinces and Territories in order of magnitude with respect to:		
	Population 1962	Total Water Power Installation 1962	Per Capita Installation 1962
1	Ontario	Québec	Québec
2	Québec	Ontario	British Columbia
3	British Columbia	British Columbia	Yukon and N.W.T.
4	Alberta	Manitoba	Ontario
5	Manitoba	Newfoundland	Newfoundland
6	Saskatchewan	Alberta	Manitoba
7	Nova Scotia	New Brunswick	New Brunswick
8	New Brunswick	Nova Scotia	Alberta
9	Newfoundland	Saskatchewan	Nova Scotia
10	Prince Edward Island	Yukon and N.W.T.	Saskatchewan
11	Yukon and N.W.T.	Prince Edward Island	Prince Edward Island

WATER POWER RESOURCES OF CANADA

BULLETIN No. 2721—63 MARCH 1964

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

WATER RESOURCES BRANCH

Water cascading over "Giant's Steps" in Paradise Valley,
Banff National Park, Alberta

WATER POWER RESOURCES

OF CANADA

BULLETIN No. 2721—63 MARCH 1964

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES

WATER RESOURCES BRANCH

The following bulletins are issued annually by the Water Resources Branch:

"Development of Electric Power in Canada"
"Water Power Resources of Canada"
"Principal Power Developments in Canada"

Copies of these bulletins are available free of charge from the Director, Water Resources Branch, Department of Northern Affairs and National Resources, Ottawa 4, Canada.

Photographs were provided through the courtesy of the following organizations:

British Columbia Hydro and Power Authority
Crown Zellerbach Canada Limited
Manitoba Hydro
The Hydro-Electric Power Commission of Ontario
The Shawinigan Water and Power Company
Twin Falls Power Corporation Limited

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WATER POWER RESOURCES

OF CANADA

The Water Resources Branch of the Department of Northern Affairs and National Resources presents its annual review of Canada's water power resources and of their development to the end of 1963. Salient features such as the development of water power resources, distribution of resources in the provinces and territories, current progress in construction of generating stations, and industrial utilization of power are discussed briefly.

One of the most important factors in Canada's economic development has been the availability of large quantities of low-cost electric power. Less than 50 years ago, the Canadian economy was based essentially upon the export of agricultural products and raw materials, most of the latter going to feed the manufacturing industries of other countries; today, the part played by industry in the nation's economy is one of vital importance. The transition to a more highly industrialized economy has been accompanied by a steady expansion in electric generating facilities,

principally of hydro-electric origin. The close relationship between electric power development and industrial expansion is particularly evident in southern Québec and Ontario. Although they lack indigenous coal, these regions are the most highly industrialized in the country, largely through the development and use of their abundant water power resources.

At present, most of Canada's electric power demands are satisfied from hydro-electric sources. By the end of 1963, the country's total installed hydraulic capacity had grown to almost 28,200,000 hp.* Of this total, 1,090,000 hp. of new capacity was placed in service during 1963. Within the next few years, a number of developments, planned or under construction, will add very substantially to the nation's total hydro capacity.

The last few years have seen a marked trend towards the use of thermal facilities for generating electric power. This is due in part to the fact that most of the hydro-electric sites considered within economic transmission distance of demand centres had been developed and planners had been obliged to look elsewhere for sources of electric power to satisfy growing requirements. It is due also to increasing recognition of the benefits of integrating the operation of hydro and thermal plants. Advances in the techniques of extra-high-voltage transmission are, however, providing a renewed impetus to the development of a number of water power sites previously considered too remote. Recognizing the benefits inherent in the economic transmission of energy over long distances, the Government of Canada is co-operating with provincial authorities in carrying out studies aimed at making more effective use of Canada's water resources and solving the problems involved in establishing a national power grid.

TOTAL AVAILABLE AND DEVELOPED WATER POWER

Table I lists by province or territory the estimated total water power resources of Canada and the total existing capacity of all water power plants, determined from the records of the Water Resources Branch. Under agreement with provincial authorities, the Branch carries out hydrometric investigations on rivers throughout the country and maintains continuous streamflow records accumulated from many sources. Estimates of available power are revised as long-term streamflow records and detailed information on potential power sites are obtained. Close liaison is maintained with the Dominion Bureau of Statistics in the collection of information on developed water power and power output.

* The total thermal-electric capacity at the end of 1963 was slightly more than 6.2 million kilowatts.

TABLE I

AVAILABLE AND DEVELOPED WATER POWER IN CANADA

at 31 December 1963

Province or Territory	Available Continuous Power at 80% Efficiency		Installed Turbine Capacity hp.
	At Ordinary Min. Flow hp.	At Ordinary 6-Month Flow hp.	
(1)	(2)	(3)	(4)
British Columbia	18,200,000[a,b]	19,400,000[a,b]	3,831,326
Alberta	911,000	2,453,000	414,455
Saskatchewan	552,000	1,131,000	326,135
Manitoba	4,758,000	8,454,000	988,900
Ontario	5,496,000	7,701,000	8,247,512
Québec	12,557,000[c]	23,711,000[c]	13,176,845
New Brunswick	123,000	334,000	309,726
Nova Scotia	30,500	177,000	204,538
Prince Edward Island	500	3,000	1,660
Newfoundland	1,608,000	3,264,000	632,025
Yukon Territory	5,859,000	5,866,000	38,190
Northwest Territories	1,367,000	1,791,000	22,250
CANADA	51,462,000	74,285,000	28,193,562

a - These figures reflect the effect of possible streamflow regulation based on known storage potentials.

b - These figures undoubtedly will be revised substantially upon completion of a review of water power resources now being carried out by the Water Resources Branch and the British Columbia Water Rights Branch.

c - These figures undoubtedly will be revised substantially upon completion of a review of water power resources now being carried out by the Québec Department of Natural Resources.

Available Water Power

Column 2 of Table I lists the estimated continuous power ordinarily available during periods of low discharge under existing conditions of river flow. These estimates are based upon the "Ordinary Minimum Flow", which is the average of the mean flows for the two lowest periods of seven consecutive days in each year covered by the period of record.

Column 3 lists the estimated dependable maximum power based on the "Ordinary Six-Month Flow", which is the dependable streamflow usually available for at least six months in the year under existing flow conditions.

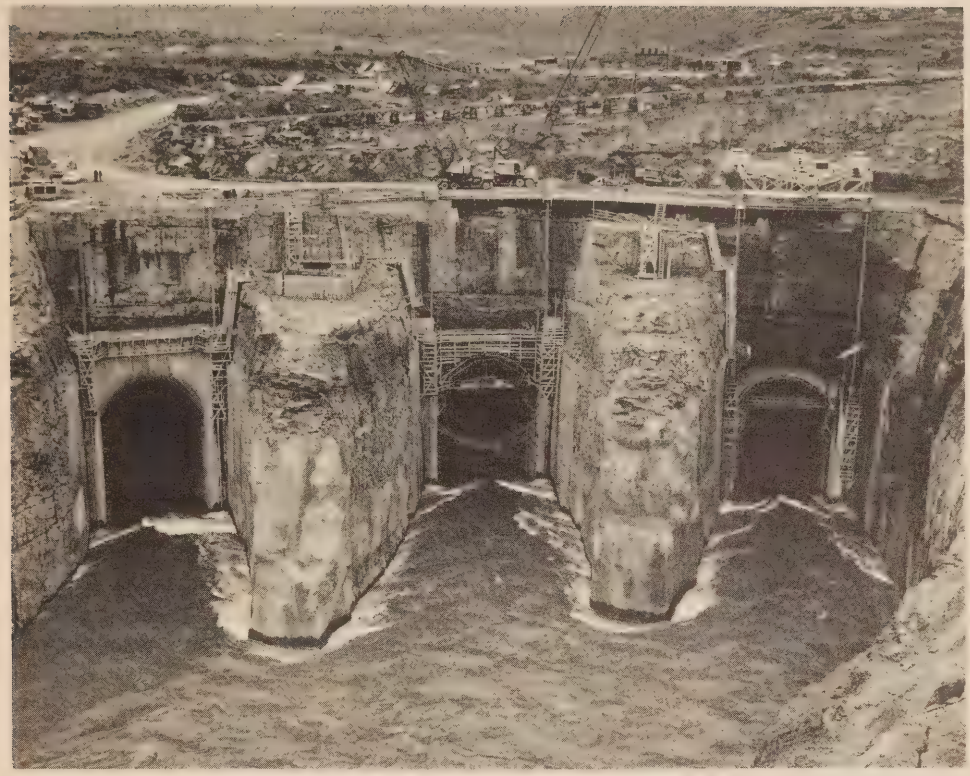
On rivers for which there are no discharge records, estimates of flow are made from available information relating to runoff in the same general area.

The hydraulic head used in calculating available power is based upon the actual drop, or feasible concentration of head, which has been measured, or at least carefully estimated, at existing falls, rapids and known power sites. No consideration has been given to possible economic concentrations of head on rivers and streams of gradual gradient, except at those locations where the available head has been definitely established by field investigations.

It should be emphasized that the figures of available power in Columns 2 and 3 represent only the minimum water power possibilities of Canada. Many unrecorded power sites exist on rivers and streams throughout the country, particularly in the less explored northerly districts. As power surveys are extended, detailed information on new sites will become available, and undoubtedly, substantial additions to present figures of available power will result. With the exception of British Columbia and the Yukon Territory, estimates of available power are based upon existing river flows and do not take into account the benefits of streamflow regulation that would result from the development of storage potential. In addition, it should be pointed out that the figures of available power do not include the power potential of major river diversions that have been investigated but not developed. For example, the potential of the Chilko River itself has been included in the total for British Columbia, but the potential of the Chilko-Homathko River diversion, quoted in some publications as 1,000,000 hp., is not included. Several other major diversion possibilities exist, particularly in British Columbia, where topographical conditions make rearrangements of flow possible.

Developed Water Power

The figures of installed turbine capacity, listed in Column 4 of



Intakes for three 48-foot diameter diversion tunnels at the
Portage Mountain development on the Peace River
in British Columbia

BRITISH COLUMBIA, traversed by three distinct mountain ranges and with, generally speaking, a high rate of precipitation, has many mountain rivers offering abundant opportunity for the development of hydro-electric power. In terms of recorded available water power resources, the province ranks second in Canada, and is exceeded only by Québec and Ontario in the amount of capacity installed.

Notable for the magnitude of their power potential are such rivers as the Columbia, Fraser, Peace and Stikine. Up to the present time, however, hydro-electric developments on smaller rivers in the southern part of the province have been called upon to supply the major load requirements of British Columbia. The immense power resources of the larger rivers have gone unused, largely due to considerations associated with international agreement on development, conflicts of interest between fisheries and power development, or because of comparative remoteness from present demand areas.

The foremost producer and distributor of electric power in British Columbia is the provincially-owned British Columbia Hydro and Power Authority, ~~with a total installed hydro-electric capacity of some 1,7 million horsepower.~~

In ALBERTA, the principal hydro-electric developments are located on the Bow River and its tributaries, and from these developments, Calgary Power Ltd. serves most of the southern part of the province. Substantial water power resources are located in northern regions of the province, but these are somewhat remote from present centres of population. Alberta's abundant reserves of coal, oil and natural gas are used to fuel the thermal-electric plants which supply a large part of the province's electric power requirements.

In SASKATCHEWAN, large water power resources exist in the central and northern parts of the province, principally on the Churchill, Fond du Lac, and Saskatchewan Rivers. In 1963, power from the first development on the Saskatchewan River was fed into the transmission network of the provincially-owned Saskatchewan Power Corporation, which serves the more settled areas of the province. These areas had previously been served by thermal-electric plants fuelled by coal, oil or natural gas, while hydro-electric power generated in the province had been used almost exclusively for mining purposes in northern areas.

Of the three Prairie Provinces, MANITOBA, with immense hydro-electric capabilities on the Winnipeg, Churchill, Nelson and Saskatchewan Rivers, is the most generously endowed with water power resources. Until recently, hydro-electric generating stations on the Winnipeg River supplied most of the electric power requirements in southern Manitoba. With the advent of high-voltage, long-distance transmission, however, it may be expected that ever-increasing amounts of power from hydro-electric stations on northern rivers will be carried south to help meet the province's constantly growing power demands.

ONTARIO, although favoured with water power resources, has developed the greater part of its recorded available power. The Hydro-Electric Power Commission of Ontario, the largest power-producing and distributing organization in Canada, operates sixty-seven hydro-electric generating stations with a combined installed capacity of approximately 7.3 million horsepower. The Commission's largest water power development is located on the Niagara River at Queenston, where the Sir Adam Beck - Niagara Generating Stations Nos. 1 and 2, and the associated pumping-generating station have a combined capacity of 2,521,000 hp. In addition to the power generated in its own plants, the Commission purchases large amounts of electric power generated outside the province, chiefly in Québec.

QUÉBEC is richest of all the provinces in water power resources, possessing more than 30 per cent of the total recorded for Canada. Québec also leads in developed water power - its present installation of almost 13,200,000 hp. representing about 47 per cent of the national total. The largest single hydro-electric installation in Canada is the Québec Hydro-Electric Commission's 2,145,000-hp. Beauharnois development on the St. Lawrence River. Also notable are the Commission's Bersimis I development on the Bersimis River with an installed capacity of 1,200,000 hp., and the Aluminum Company of Canada Limited's 1,200,000-hp.

Shipshaw plant on the Saguenay River. A major power scheme which will represent a significant advance in the development of Québec hydro-electric resources is now under construction. This scheme, involving the harnessing of the headwaters of the Manicouagan and Outardes Rivers, will permit the eventual installation of some 7,325,000 hp. of new capacity at developments on the two rivers.

Power production in the province is facilitated by the regulation of streamflow by the Québec Department of Natural Resources through the storage dams which it owns and operates.

In 1963, the Government of Québec, through the Québec Hydro-Electric Commission, purchased the assets of the major private power-producing companies in Québec.

The water power resources of NEW BRUNSWICK and NOVA SCOTIA, although small in comparison with those of other provinces, are a valuable source of energy and are being well utilized. Numerous rivers in both provinces provide moderate-sized power sites either within economic transmission distance of the principal cities and towns or advantageously situated for use in development of the timber and mineral resources. These provinces also are favoured with abundant indigenous coal supplies. In PRINCE EDWARD ISLAND, there are no large streams and consequently water power plants are limited in size to those used for small mills.

The water power resources of NEWFOUNDLAND, determined on the basis of limited streamflow data, are estimated to be of considerable magnitude. On the island, although the length of the rivers is generally not great, topography and runoff are favourable for hydro-electric power development. Of the substantial capacity installed, a very large portion serves the pulp and paper industry. In Labrador, the Hamilton River and its tributaries, for the most part undeveloped, constitute one of the largest sources of water power in Canada.

The YUKON TERRITORY and NORTHWEST TERRITORIES, which together comprise Canada's northland, possess extensive water power resources. Power from present developments is used almost exclusively to satisfy the needs of local mines and adjacent settlements. Due to the lack of developed native fuel sources and to transportation difficulties, water power is of special importance in the development of mining areas such as Yellowknife in the Northwest Territories and Mayo in the Yukon Territory. In 1948, to encourage the development of the resources of northern Canada, the Federal Government established what is now the Northern Canada Power Commission, to be responsible for the construction and management of public utility plants. The Deputy Minister of Northern Affairs and National Resources is Chairman of the Commission and the Director of the Water Resources Branch is a Member.

In the YUKON TERRITORY, most of the resources are located on

the Yukon River and its tributaries. The possibility exists of diverting the headwaters of the Yukon River through the Coast Mountains to utilize a high head near tide-water in northern British Columbia. Such a development, however, would affect adversely the potential of sites on the main river.

Resources in the NORTHWEST TERRITORIES have not been surveyed to the same extent as those in the Yukon Territory, but they are nevertheless known to be of considerable magnitude. Extensive water power resources exist on rivers flowing into Great Slave Lake. Of major significance is the hydro-electric potential of the South Nahanni River, which drains to the Mackenzie River via the Liard River. On the basis of preliminary investigations, it is estimated that, with total regulation and complete use of the head susceptible of development, the hydro-electric potential of the South Nahanni River would total at least one million continuous horsepower. Indications are that the rivers draining the District of Keewatin, north of Manitoba, also will contribute materially to the total power potential of the Northwest Territories.

DEVELOPMENT OF WATER POWER RESOURCES

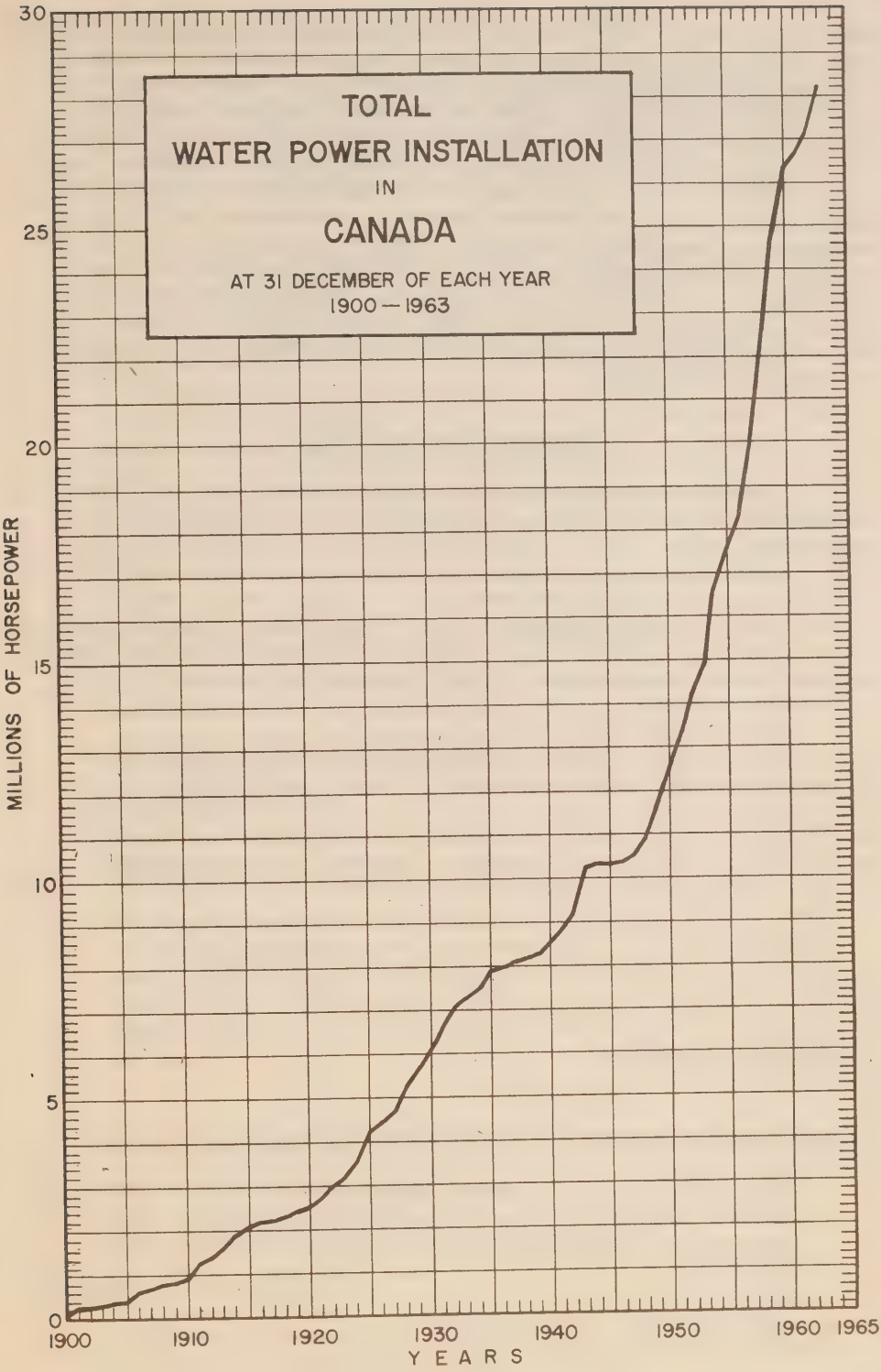
Water power development in Canada has undergone remarkable and sustained growth since the beginning of the century. The diagram on page 15 illustrates this growth in terms of the expansion in installed turbine capacity for the period 1900 to 1963.

Historical Summary

From a modest 177,323 hp. installed at the end of 1900, Canada's total turbine capacity has grown to 28,193,562 hp. at the end of 1963.

Over the years, the rate of growth in the total water power capacity in Canada has tended to accelerate. The average annual increase from 1900 to 1905 was 56,000 hp. From 1906 to 1922, the rate increased sharply to about 150,000 hp. annually, due largely to improvements in electric power transmission and to the increasing emphasis on large hydro-electric stations. As a result of the heavier demand for electricity during the prosperous 1920's the rate of installation increased appreciably in 1923 and continued at a fairly uniform rate of 377,000 hp. per year until 1935.

As a large-scale hydro-electric project requires a long construction period, completion of the project tends to lag behind the electric power demand which responds quickly to general economic conditions. The fall in power demand during the early 1930's is an illustration of this tendency - projects under way were completed but the economic


TOTAL
WATER POWER INSTALLATION
IN
CANADA
AT 31 DECEMBER OF EACH YEAR
1900 — 1963
MILLIONS OF HORSEPOWER
30
25
20
15
10
5
0
1900
1910
1920
1930
1940
1950
1960
1965
YEARS

depression resulted in a low rate of installation during the period 1936-1939. The great demand for power for war purposes accounts for the high average rate of increase of 481,000 hp. per year during the period 1940-1943. Few new developments were initiated in the latter years of the war or in the immediate post-war period, so that, from 1944 to 1947, only a small amount of new capacity came into operation. Soon after the war, however, the programme of construction of hydro-electric plants gained momentum, and the results are apparent in an average annual rate of installation exceeding 1,200,000 hp. during the period 1948 to 1960. In sharp contrast are the comparatively moderate net totals of 294,650 hp. and 415,468 hp. of new capacity put into service in 1961 and 1962 respectively. The previous high rate of installation was resumed in 1963, however, when a total of 1,090,000 hp. of new capacity was brought into service.

Progress During 1963

Canada's total hydro-electric turbine capacity rose by 1,090,000 hp. in 1963, with an accompanying rise of 784,550 kw. of hydro-electric generating capacity. This large increase marked a return to the high rate of installation set in the post-war years, reversing the slow-down in completions recorded for 1961 and 1962. The high rate is expected to continue with the planned installation, in 1964, of some 900,000 hp. of turbine capacity, and 650,000 kw. of generating capacity, and with the proposed installation of almost 12 million additional horsepower within a few ensuing years.

The following summary lists the hydro-electric developments completed or under construction during 1963, or proposed for construction within the next few years. A detailed review of new and prospective water power development is presented in Water Resources Branch Bulletin No. 2720-63 "Development of Electric Power in Canada - Progress Report 1963", issued in January 1964.

British Columbia

CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA LTD.

Waneta, Pend d'Oreille River: Installation of the third generating unit was completed in May, bringing the total turbine capacity of this station to 370,000 hp. and the total generator capacity to 216,000 kw.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

1. Portage Mountain, Peace River: During the year, the main river flow was diverted through three 48-foot diameter tunnels, thereby allowing a start on the main dam. First power will become available in 1968 and the total capacity, estimated at 3,000,000 hp. for turbines and 2,300,000 kw. for generators, will be in use by 1979.

2. Columbia River: Negotiations aimed at clarifying and adjusting arrangements proposed earlier with regard to the Columbia River Treaty were carried on between Canada and the United States during 1963. The Treaty, signed in 1961, provides that Canada would receive one-half of the power benefits accruing in the United States from the regulation of 15.5 million acre-feet of water stored in Canada behind the proposed Duncan Lake, High Arrow and Mica Dams on the Columbia River.. In addition, Canada would receive one-half the value of the estimated flood damage prevented in the United States through operation of the proposed dams for flood control. Canada has not yet ratified the Treaty.

WEST KOOTENAY POWER AND LIGHT COMPANY LIMITED

Lower Bonnington, Kootenay River: The Company is replacing the wood crib dam at this development with a concrete structure, making provision at the same time for future installation of a 25,000-hp., 19,000-kw. unit. Work on the new dam will be completed by April 1964.

CITY OF REVELSTOKE

Cranberry Creek: The City has begun construction of a storage dam on the headwaters of Cranberry Creek. While the City's present 5,800-hp. plant downstream will benefit from the additional storage, the increase in storage will be particularly significant should the City decide to increase the installed capacity of the plant.

Alberta

CALGARY POWER LTD.

Big Bend, Brazeau River: The storage dam was completed and construction of the powerhouse was continued. Water from the

reservoir will be carried by a 12-mile long canal to the power plant at which a single 210,000-hp., 150,000-kw. unit is expected to be brought into service late in 1964. Installation of other large units will necessitate increasing the height of the storage dam above the level to which it is now built.

At the reservoir outlet, an 11,000-hp. pump-turbine unit with a generator rating of 9,720 kw. is being installed. Under operating conditions, when the reservoir level is higher than the canal elevation, the unit will function as a generator; when the water surface in the reservoir is lower than that in the canal, the unit will be used as a pump to raise water to the canal.

Saskatchewan

SASKATCHEWAN POWER CORPORATION

1. Squaw Rapids, Saskatchewan River: First power from this site became available in 1963. Four units consisting of 46,000-hp. turbines and 33,500-kw. generators were in operation by year's end, with two other similar units scheduled for completion in mid-1964. There is provision in the powerhouse for a total of eight units.

2. Coteau Creek, South Saskatchewan River: Closure of the dam at this site is scheduled for February 1964. The dam and reservoir are being built by the Prairie Farm Rehabilitation Administration for irrigation purposes, but three 84,000-hp., 62,200-kw. hydroelectric units are being installed by the Saskatchewan Power Corporation as part of the development. Operation of the first two units is scheduled for 1967, and the last for 1969.

Manitoba

MANITOBA HYDRO

Grand Rapids, Saskatchewan River: Construction of this development is proceeding on schedule. Initial installation will consist of three 150,000-hp., 110,000-kw. units, two of which are scheduled to go into service late in 1964 and the third late in 1965. Provision is being made for a fourth unit.

GREAT LAKES POWER COMPANY LIMITED

Hogg, Montreal River: Construction of a single-unit, 21,750-hp., 15,000-kw. plant got under way in 1963, with initial operation scheduled for December 1964.

Québec

QUÉBEC HYDRO-ELECTRIC COMMISSION

1. Carillon, Ottawa River: Six more units were installed at the site in 1963, raising turbine capacity to 600,000 hp. and generating capacity to 450,000 kw. in ten units. Ultimate turbine capacity of 840,000 hp. with 630,000 kw. of generating capacity will be reached in 1964.

2. Rapid II, Ottawa River: Construction commenced on the extension of this plant. By July 1964, the fourth and final unit will be in operation, raising the plant's turbine capacity to 64,000 hp. with a generating capacity of 48,000 kw.

3. Manicouagan and Outardes Rivers: Considerable progress was made on construction of a multi-development project designed to realize some 5.1 million horsepower (3.9 million kilowatts) at five sites on the Manicouagan River and approximately 2.2 million horsepower (1.8 million kilowatts) at three sites on the Outardes River.

   Manicouagan 5: At this site, located just below the outlet of Manicouagan Lake, construction progressed on schedule for the development of eight units with total turbine capacity of 1,800,000 hp. and generator capacity of 1,344,000 kw. First power is expected to be realized in 1968, with 1971 set as the completion date for the entire plant.

   Manicouagan 2: This plant, located only 11 miles from the river's mouth, will be the first of the new plants to supply power. In July 1965, the first of eight 170,000-hp., 140,000-kw. units will be in operation. The entire turbine capacity or 1,360,000 hp., with 1,120,000 kw. of generating capacity, is expected to be in service by 1967.

   Manicouagan 3: Plans for the development of this site, 50 miles from the River's mouth, call for the installation of seven 210,000-hp., 160,000-kw. units.

   McCormick: This development, owned by the Manicouagan Power

Company, has an existing total turbine capacity of 292,400 hp. and a generating capacity of 191,250 kw. in five units. Québec Hydro has commissioned the Company to bring the plant to full capacity by the addition of two more units totalling 150,000 hp. (104,000 kw.).

Manicouagan 1: This plant, proposed for development by Québec Hydro, would utilize the same headpond as the McCormick Station. Preliminary surveys for this new plant have begun, and tentative plans call for four units with a total turbine capacity of 300,000 hp. and a total generating capacity of 208,000 kw.

Outardes 58 and Outardes 45: Preliminary studies are nearing completion at the former and are well under way at the latter for development of 800,000 hp. (600,000 kw.) and 1,040,000 hp. (880,000 kw.) respectively.

Outardes Falls: This development, owned by the Québec North Shore Paper Company, has an existing capacity of 70,600 hp. (50,000 kw.) in two units. As a result of benefits which will accrue from upstream storage, three additional units, each with a turbine rating of 135,000 hp. and a generator rating of 104,000 kw., are proposed for installation at this site.

New Brunswick

NEW BRUNSWICK ELECTRIC POWER COMMISSION

Mactaquac, Saint John River: Construction is expected to start in 1965 for the development of 504,000 kw. in six units. The schedule calls for the first unit to come on line early in 1968.

MAINE AND NEW BRUNSWICK ELECTRIC POWER COMPANY LTD.

Tinker Falls, Aroostook River: Construction was begun in 1963 for the extension of this plant. When completed early in 1965, the plant capacity will have increased to 47,000 hp. (34,640 kw.) from the present capacity of 14,000 hp. (10,040 kw.).

Nova Scotia

NOVA SCOTIA POWER COMMISSION

Consideration is being given to the construction of two developments, one at Riverdale on the Sissiboo River and the other at Wreck Cove on Wreck Cove Brook. Plans for Riverdale call for installation of a single 8,000-hp. unit, while estimates for the Wreck Cove plant indicate a possible ultimate capacity of 90,000 hp. There is as yet no indication of when construction of either development will commence.

NOVA SCOTIA LIGHT AND POWER COMPANY LIMITED

1. Lequille, Allain (Lequille) River: Preliminary construction was carried out at this site in 1959. The need for power from this 7,500-hp. development was rendered less urgent, however, by interconnection of power systems in Nova Scotia and New Brunswick, and the project is not likely to be completed before 1970.

2. Nictaux, Alpena River: The Company is considering the installation of a single 6,500-hp. unit at this site, but this unit is not expected to be installed before 1968.

Newfoundland

TWIN FALLS POWER CORPORATION LIMITED

Twin Falls, Unknown River: The second stage of development at this site was completed in 1963 with the installation of the third and fourth units. This development, located in Labrador, now has a total turbine capacity of 240,000 hp. and a generator capacity of 187,200 kw.

NEWFOUNDLAND LIGHT AND POWER COMPANY LIMITED

Sandy Brook: Construction at this site on the island portion of the province was completed in 1963. The plant consists of an 8,000-hp. turbine driving a 5,950-kw. generator.

Spring flood-waters rush through the sluices at the Twin Falls hydro-electric development on the Unknown River in Labrador

NEWFOUNDLAND POWER COMMISSION

Head Bay d'Espoir, Salmon River: The Commission is planning to construct a development which is expected to consist of up to 350,000 hp. Construction is expected to begin in 1964, with initial power available in 1967.

Northwest Territories

NORTHERN CANADA POWER COMMISSION

Twin Gorges, Taltson River: Investigations are complete and construction of a 25,000-hp., 18,000-kw. hydro-electric plant is scheduled to begin early in 1964 at this site. Power from the new plant is expected to be available by December 1965.

COAL EQUIVALENT OF DEVELOPED WATER POWER

At present, large amounts of electric energy are generated by thermal plants, most of which are fuelled by coal. For the purpose of illustrating the importance of hydro-electric energy to the nation's power economy, it may be helpful to express the total hydro-electric energy generated in Canada in 1963 in terms of the amount of coal that would have been necessary to produce the same amount of energy in steam plants.

The total amount of electric energy generated from water power in Canada during 1963 was approximately 116,000 million kilowatt-hours. Assuming that one pound of bituminous coal rated at 12,000 B.T.U. per pound is required to produce one kilowatt-hour of electricity by thermal-electric generation, the total 1963 water power output would be equivalent to the burning of 58 million tons of such coal. This theoretical quantity would be in addition to the estimated total of 23,500,000 tons of coal of all types actually consumed in 1963.

UTILISATION OF INSTALLED WATER POWER CAPACITY

Table II lists the water power capacity in the provinces and territories under the two divisions "Utilities" and "Industries" and indicates the relationship between installed water power capacity and population in Canada.

Utilities

The classification "Utilities" in Column 2 of Table II, refers to companies, municipalities or individuals who sell most of the power they develop. In some instances it also includes certain subsidiary companies whose main purpose is to develop and sell power to a parent company for industrial purposes. The total of 21,972,661 hp. of installed capacity in hydro-electric plants operated by utilities represents 78 per cent of Canada's total installed capacity at 31 December 1963.

Industries

The classification "Industries" in Column 3 of Table II refers to those companies or individuals who develop power mainly for their own use. While the figures indicate that industries have developed only 22 per cent of Canada's total installed water power capacity, it should be emphasized that, in addition to the power generated in their own plants, industries purchase large amounts of power from utilities. For example, of the total of 39,884 million kilowatt-hours of electric energy made available in 1962 by the Hydro-Electric Power Commission of Ontario, almost half was purchased by industrial customers, either directly from the Commission or through municipal electric utilities or local systems.

The pulp and paper industry in Canada is one of the world's great industrial enterprises and is one of the foremost users of hydro-electric energy in Canada. Total mill capacity for the production of newsprint paper is considerably greater than that of any other country in the world,

Pulp and paper development with associated power plant
at Ocean Falls in British Columbia

INSTALLED WATER POWER CAPACITY IN RELATION TO POPULATION

The figures listed in the column headed "installation per thousand of population" in Table II reflect in part the extent and character of the use of water power in the provinces and territories. In terms of installed water power capacity per thousand of population, Canada with an average of 1,490 hp. at the end of 1963, is second only to Norway, the figure for the latter being approximately double that for Canada.

On the basis of world statistics for 1962, Canada's total installed water power capacity, about half that of the United States, ranked second amongst the countries of the world. For 1963, however, there are indications that Canada will fall to third place, behind the United States and the Union of Soviet Socialist Republics.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